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Editorial

This second issue of the REAAA Journal for 2005 contains six papers.

The paper 'Privatisation of Road Facilities – the Malaysian Experience' was presented at the 4th Heads of Road Authorities (HORA) meeting in Bangkok in June this year. The paper describes the road privatisation mechanism in Malaysia, the approach adopted, lessons learnt in previous years and how the recent Asian economic crisis has affected the implementation of road privatisation projects.

The paper 'Development of Hourly, Daily and Monthly Factors and its Application to Prediction Model for Motorcycle Accidents at Junctions in Malaysia' describes the development of hourly, daily and monthly factors representing volume-variation patterns of traffic in typical States in Malaysia. A simple and quick method for the estimation of the Annual Average daily Traffic (AADT), based on short traffic counts using the appropriate conversion factors of hourly traffic volume, is presented as well as an application of this technique in the development of a prediction model for motorcycle accidents at non-signalised junctions in Malaysia.

The highway authority of the Japanese Government is dealing with the implementation of Electronic Toll Collection (ETC) as one of the top priority issues of the highway administration. Since the introduction of commercial operation of ETC in 2001, a great deal of effort such as several promotional campaigns with public subsidies or instalment of ETC gantry systems has been put into promoting the system. This paper, the first paper from Japan to be published in the Journal, describes the introduction of the ETC system into tollways in Japan. Since the introduction of the ETC toll system in 2001, the effects and impacts on the community have been much larger than initially envisaged.

The next paper addresses the issue of community road safety. Basic principles relating to objectives and structures developed in an Austroads project are discussed and progress made in a program in Tasmania, Australia, which is based on these principles, is reported. The relevance for developing countries is also discussed.

Another paper from Malaysia describes a study undertaken to examine the effectiveness of providing a continuous paved shoulder to reduce motorcycle conflicts at T-junctions. The effects of the treatment on motorcycle speed and paved shoulder usage were also studied. The study revealed a statistically significant reduction in overall traffic conflicts as well as particular conflict types after the treatment. These results supported the hypothesis that this treatment does reduce overall conflict.

One of the primary goals of REAAA is to improve the delivery of technical services to members. The final paper discusses the general issue of training needs for the region, activities to date and planned future activities. Possible avenues for conducting these activities, including the ASEAN Regional Road Safety program, are also discussed. Also included in the paper are the results of a questionnaire completed by delegates at the recent HORA meeting on the major issues that could be addressed in training courses or seminars.

The Editorial Panel continues to seek papers and technical notes for publication in the Journal. The membership of the Editorial Panel follows. REAAA members interested in submitting a paper should seek advice from the appropriate member(s) of the Editorial Panel. The Panel is striving to publish at least one paper from each Chapter or region each year.

Kieran Sharp
Chairman REAAA Technical Committee

MEMBERSHIP OF EDITORIAL PANEL: REAAA JOURNAL - MAY 2005

PRIVATISATION OF ROAD FACILITIES – THE MALAYSIAN EXPERIENCE

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Malaysian Highway Authority

ABSTRACT

Road infrastructure has been the main backbone of Malaysian development since its independence. In line with the national vision to achieve developed nation status by 2020, the Malaysian Government has invested heavily in the road infrastructure sector, thereby bringing about greater economic growth. The privatisation policy introduced in 1983 to accelerate development, particularly in the road sector, did not see much success initially. It was only after the privatisation of the North South Expressway in 1988 that a proliferation of private sector participation in road projects occurred.

The development of roads through privatisation during the 1990s has resulted in a two-fold increase of total toll road length. This could not have been achieved if only the Government Consolidated Fund was used to finance projects. Today, there have been 25 toll highway concessions awarded to the private sector, with 19 already in operation. All these toll highways come under the jurisdiction of the Malaysian Highway Authority which supervises, monitors and ensures the compliance of the concessionaire to the provision of the agreement.

This paper briefly describes the road privatisation mechanism, the approach adopted, lessons learnt in previous years and how the recent Asian economic crisis has affected the implementation of road privatisation projects. The experiences and shortcomings identified during the crisis has prompted the Government to review the financial package and to impose stringent conditions on the financial resources and capabilities of the concessionaires. These factors provide assurance to investors and leading institutions that the projects would take-off. Following initial public resistance to new toll roads public opinion surveys are now a prerequisite in any road privatisation proposal to gauge its acceptance. Road privatisation and its implementation in Malaysia have highlighted a broad spectrum of issues, challenges and experiences that could prove beneficial in similar development efforts in REAAA member countries.

1. INTRODUCTION

Between 1988 and 1996 Malaysia achieved a Gross Domestic Product (GDP) growth of 8.9% per annum. The high economic growth during this period was accompanied by a structural transformation of the Malaysian economy, from one relying on the production and exports of primary commodities to a more modern industrial economy. More importantly, per capita income in nominal terms increased from RM1,106 in 1970 to RM11,835 in 1988[1]. The higher than anticipated economic growth enjoyed by Malaysia has resulted in road capacity constraints as a result of a marked increase in vehicle ownership and usage. The Government launched several strategies under its Second Outline Perspective Plan (1991-2000) where due emphasis was given to increasing capacity and improving efficiency through integrated and co-ordinated planning. Transportation strategies focusing on multi-modalism were introduced to promote greater use of public transportation through the systematic integration of the transport system and operation involving bus, train and rail services.

[1] *In 1988, 1USD = RM2.50.*

Road transportation accounts for 96% of the total passenger and goods transported in Malaysia. When the Government faced budgetary constraints in the highway network expansion program, it entrusted a bigger role to the private sector in line with the aims of the privatisation policy to further accelerate road development through fast-track approaches. In 2003, Malaysia had a road network infrastructure of 77,200 km (Figure 1) of which 75.0% was paved roads. This included 1,490 km toll highways (Figure 2) including approximately 1,100 km of interurban highways.

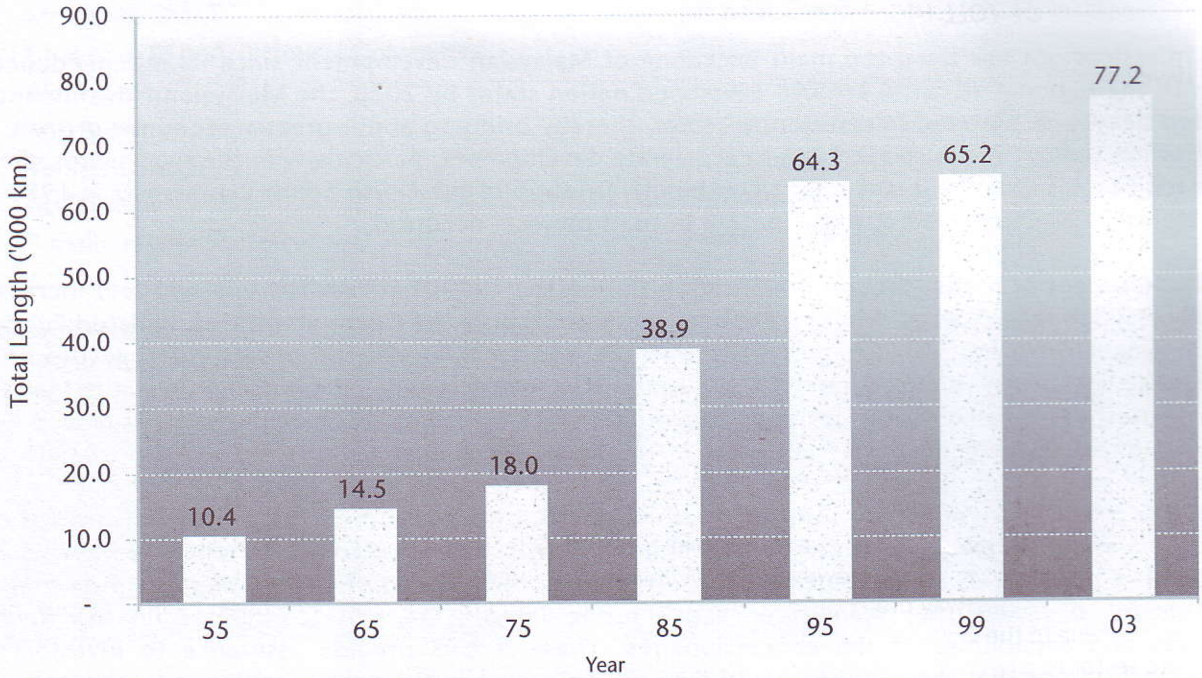

Figure 1: Total Road Length In Malaysia ('000km)

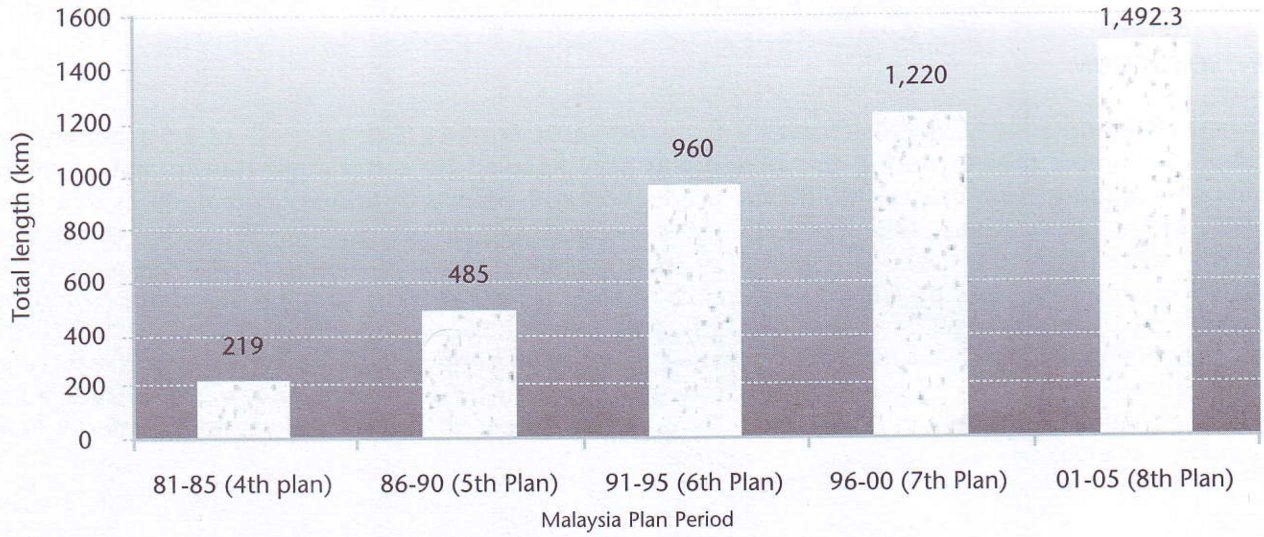

Figure 2: Total Toll Highway Network in Malaysia

2. ROAD DEVELOPMENT IN MALAYSIA

Road development in Malaysia is based on a series of five- year planning periods. Comprehensive planning of roads in the country only began after the formation of Malaysia beginning with the First Malaysia Plan (1966-1970). During this period, the General Transportation Study (1967) laid the groundwork for consistent policies in road development. Whilst the early five-year plans were mainly concerned with the development of roads in regional land schemes and undeveloped hinterland linking them to the national network, the emphasis of later plans (fourth to seventh from 1980-2000) was on upgrading and extending the road system to facilitate the efficient movement of people and goods. A central feature of these plans was the development of interurban highways.

Up to 1988, the Government was directly involved in the construction and operation of toll highways, through the Malaysian Highway Authority. With the onset of privatisation on a large scale from 1988 onwards, all new toll highway projects were undertaken by the private sector. There have been 25 toll road concessions awarded to the private sector to date with 19 already in operation. Most of the toll highways, with respect to supervision, monitoring and adherence to the provisions of the concession agreements, come under the jurisdiction of the Malaysian Highway Authority.

3. DEVELOPMENT OF TOLL HIGHWAY PROJECTS

Road development was traditionally financed by the Government through its consolidated funds or through borrowings from off-shore sources. However, the development of roads was restricted due to limited funding and progress was slow. The Government then decided that a direct user charge in the form of toll collection would be more appropriate to finance highway development projects, The idea of the private sector financing projects through privatisation was mooted in 1977 but was not successful due to the heavy capital investment required and the return was slow. The Government then decided to set up a special-purpose agency to be responsible for this task and, as a result, the Malaysian Highway Authority (MHA) was formed.

The North South Expressway was identified as its first project and this commenced in 1981. However, the Government faced a heavy financial burden due to the high capital outlay and slow capital recovery coupled with delays in the completion of the project. It was during this period that the Government reactivated the concept of private sector financing through privatisation and, as a result of this privatisation exercise, the North South Expressway project (848 km) was privatised in 1988. The concession is based on the build-operate-transfer method that also covers the taking over the management of completed stretches from the MHA and completing the remaining stretches.

Privatisation of toll highway projects actually began in 1984 with the awarding of the 15.3 km long North Straits Klang Bypass, located in the Klang Valley. However, the privatisation momentum only gained momentum with the awarding of the North South Expressway project. Toll highway development in Malaysia has been given a boost during the last decade largely due to the Government's privatisation policy. As demand for better and faster travel on roads increased, the private sector responded by investing heavily in toll road infrastructure projects, resulting in many other highway projects being privatised progressively as shown in Figure 3.

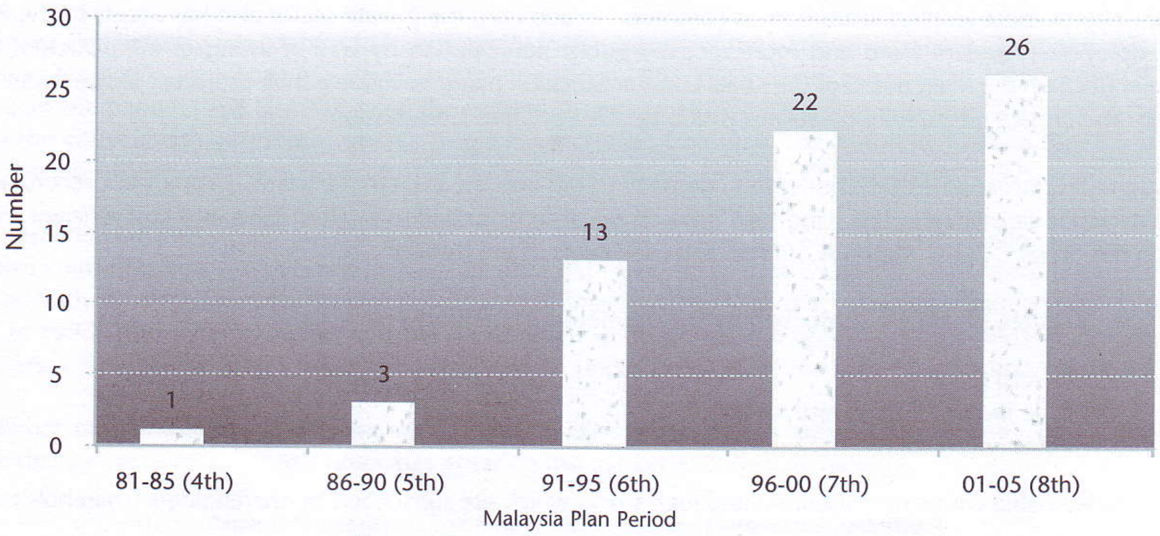

Figure 3: Progression of Toll Highway Projects
(one highway concession ended its concession period in 2003)*

The development of toll highways forms part of the overall road network infrastructure; the overall development of the road network is guided by the Highway Network Development Plan which was formulated in 1993 by the Highway Planning Unit of the Ministry of Works. Long-term integrated planning that incorporates a total approach was adopted in the various development plans, where the supply-driven approach formed the basis for the expansion of road capacity to ensure availability of supply upon demand. The push by the Government has provided significant opportunities for private sector involvement in the financing, construction, maintenance and management of road infrastructure.

When fully completed, the value of the 25 privatised toll highway projects is estimated to be approximately RM24 billion[2] (US$6.30M). This privatisation scenario was made possible with the enactment of several Acts of Parliaments

[2] *In 2000, 1USD = RM3.80*

such as the Federal Roads (Private Management) Act 1984, which transferred the Government's business to the private sector.

4. FINANCING TOLL HIGHWAY PROJECTS

When the Government initiated privatisation as a national policy in 1983 as a new approach in national development, its aim was to stimulate the growth of the private sector and to promote overall economic efficiency. The implementation of toll highway privatisation is based on the build-operate-transfer method and it includes both the upgrading existing roads and the construction of new roads. Proposals for privatisation of road projects can be initiated by the Government or by the private sector. Proposals initiated by the Government are based on open bidding whilst proposals initiated by the private sector are based on first-come first-serve basis where, if the initial proposal is accepted by the Government, then they will be given an exclusivity (within a fixed time period) to prepare a more comprehensive proposal for further scrutiny and negotiation.

With the advent of privatisation, from 1988 onwards, toll highway development was undertaken solely by the private sector. The concession companies are responsible for obtaining all the finance, both debt and equity, necessary to construct, operate and maintain the highways. Therefore, the private sector's main responsibility in raising finance is to ensure the viability and bankability of the projects, and having a financial model which passes a sensitivity analysis test involving factors such as fluctuations in toll revenue, increase in cost, delays in construction and changes to the concession agreement.

There are various methods of financing available to the private sector involved in infrastructure projects. Financial consultants/advisers play a major role in guiding the concessionaires to the cheapest sources of funding. In this respect, the Government's participation in the projects by way of the concession agreement has given projects the impetus to proceed. The various forms of Government support formulated to suit the uniqueness of the various privatised projects, play a critical role in deciding the course of the methods of financing available to the private sector.

By far, the most common and traditional source of funds for financing toll road projects is commercial banks, which are capable of committing funds up to 15 years. For large amounts, an integrated proposal in the form of a syndicated loan from two or more lending institutions is common. In addition, the private sector also has access to the Pension Fund, Employees Provident Fund and more recently public participation by way of listing of infrastructure project companies (IPC) on the Main Board of the Kuala Lumpur Stock Exchange to finance their projects. However, to qualify for listing, the project has to fulfil guidelines issued by the Securities Commission.

The listing of IPC has enabled the concession company to tap into the capital markets without a track record and this is of tremendous assistance in financing new projects because its provides an alternative and cost-efficient mode of financing the project. Other methods of financing road projects are through:

a) right issues, which are subscribed by the promoters of the projects;

b) commercial loans:
   (i) issue facility or fixed rate load
   (ii) notes issue facility

c) redeemable cumulative subordinated loan stock, which are subscribed by shareholders (shareholders loan)

d) equity contribution

e) capital market.

5. PROJECT RISK AND FINANCING

The private sector's main responsibility in raising finance is to ensure the financial viability of the project by having a financial model which passes a sensitivity test analysis involving the following factors:

a) Fluctuation in Toll Revenue

The forecast normally considers three scenarios: base case, high case and low case;

b) *Increases in Costs*
Cost increases can be attributed to construction costs and interest rate costs. There should be an appropriate margin of comfort as a buffer against increase in material costs and inflation;

c) *Delays in Construction*

Delays in completion of the project mean a shortfall in revenue collection. Therefore the worst case versus the best case scenarios have to be presented;

d) *Changes to Concession Agreement*

The proposal would have to be robust enough to cater for changes to the concession agreement; example, deferment of toll rate increase.

Sensitivity analysis is used to determine the viability and success of the projects to variations in the date used in the analysis. The study will reveal the importance of each factor and its degree of risk and options to be adopted to overcome it. Reducing uncertainty is thus important as high-risk projects requires a large amount of finance.

In Malaysia, Government support extended to toll highway concessions has reduced the risk or helped in limiting the risks associated with toll highway projects. The various forms of Government support provided has played a major role in improving project viability and financial viability. It should be noted here that the support provided should not be taken for granted and it also varies from project to project depending on the individual project viability and the necessity of the project to the nation.

Examples of Government support extended to concession companies are undertakings pertaining to toll rate structure, support loans, traffic volume guarantee (in the form of a soft loan), land acquisition costs, the taking over of existing highway sections and undertakings by Government on termination.

6. CONTRIBUTION AND BENEFITS OF TOLL HIGHWAY PROJECTS

6.1 Contribution to construction industry

The construction industry has contributed significantly to the growth of the national economy. Since the privatisation of highway projects commenced in a significant manner since 1988, the industry achieved an average growth rate of 23.2% over the period 1988 to 1997, until the economic crisis of 1997-1998 came into effect. The contribution to GDP by the construction industry at today's prices has increased from RM 2.87 billion in 1988 to RM18.5 billion in 1997. The industry's percentage share of GNP has increased from 3.1% in 1988 to 6.6% in 1997.

The construction industry employed 0.8 million people in 2000 or about 8.6% of the total workforce in the country. It has also contributed to a significant increase to the pool of expertise in the country. The number of contractors registered with the Construction Industry Development Board (CIDB), Malaysia, currently stands at 39,340 up from 20,518 in 1996. The majority (55%) are small contractors undertaking jobs up to a value of RM100,000.00. Large contractors, which account for 4.2% of the total number, undertook 74% of the total construction volume.

The number of professionals and those with tertiary qualifications in the construction industry has continued to increase due to the number of new graduates entering the market as shown in Table 1.

Table 1: Professionals and Degree Holders in the Construction Industry [3]

Job Creation/Demand	1997	1998	1999
Professional Engineers	8,611	9,038	9,104
Professional Architects	1,471	1,479	n.a.
Professional Quantity Surveyors	709	728	736
Engineering Degree	21,374	32,066	24,319
Architecture Degree	966	1,098	n.a.
Quantity Surveying Degree	382	441	460

[3] *Source : Board of Engineers, Board of Architects and Board of Surveyors.*

The construction industry has also contributed to a growth in the number of construction related service companies. Table 2 shows the performance of the companies. The data in the Table shows that the combined consultancy services has contributed to 35,000 job opportunities and has seen a significant increase of 48% over 5 years.

Table 2: Statistics of Consultancy Services [4]

Type of Consultancy	1991	1992	1994	1996
Engineering	419	445	484	505
Gross Output (RM million)	629	705	1,007	1,441
No. of Employees	11,041	11,393	13,193	16,295
Architectural	380	401	549	580
Gross Output (RM million)	273	301	434	683
No. of Employees	4,255	4,686	6,435	7,457
Quantity Surveyors	377	422	450	499
Gross Output (RM million)	337	384	486	628
No. of Employees	8,275	9,031	9,968	11,201

6.2 Contribution to national economy

The country's investment in infrastructure has borne fruit by ensuring a continued high economic growth through the support of an accelerated economic development of the country. Additionally, the stock of infrastructure, including road network development and transportation, has assisted in the economic recovery of the country during the Asian economic crisis of 1997-1998, without which the recovery would have been much delayed. Table 3 shows the GDP growth rate before and after the crisis. The data in the Table suggests that the economic recovery was very much rapid in countries which had a better infrastructure network.

Table 3: Comparison of GDP Growth Rates

Country	1996	1997	1998	1999	2000
Malaysia	10.0	7.3	- 7.4	6.1	8.3
Singapore	7.5	8.4	0.4	5.4	7.5
South Korea	6.8	5.0	- 6.7	10.7	8.6
Philippines	5.8	5.2	- 0.6	3.3	3.9
Thailand	n.a	- 0.5	- 7.8	0.9	2.5
Indonesia	n.a	4.7	- 13.2	0.5	n.a

6.3 Benefits to road infrastructure network and public

Based on the investment made by the Government and the private sector as shown in Figure 4, private sector participation in toll highway development and funding has accelerated the growth of the highway network across the country by two-fold over the last decade. The country also saw early completion of highway projects as incentives are built into the concession agreement; for example, early collection of tolls may commence upon completion of the project.

The Government therefore needs to only focus on the development of roads that are less viable or obligated to develop for social reasons, with the private sector funding the more viable projects. This in turn has acted as a catalyst for further development of the economy. The involvement of the private sector in road infrastructure projects has had the effect of reducing the financial burden on the Government.

Prior to the Asian economic crisis, the savings in terms of capital expenditure in highway projects amounted to RM16.7 billion as shown in Figure 5. This represents the investment by the private sector in toll highway projects. Additionally, the Government has also enjoyed savings in terms of annual operating expenditure, which amounted to RM555 million in 1999.

[4] *Source : 1999 Yearbook of Statistics, Department of Statistics*

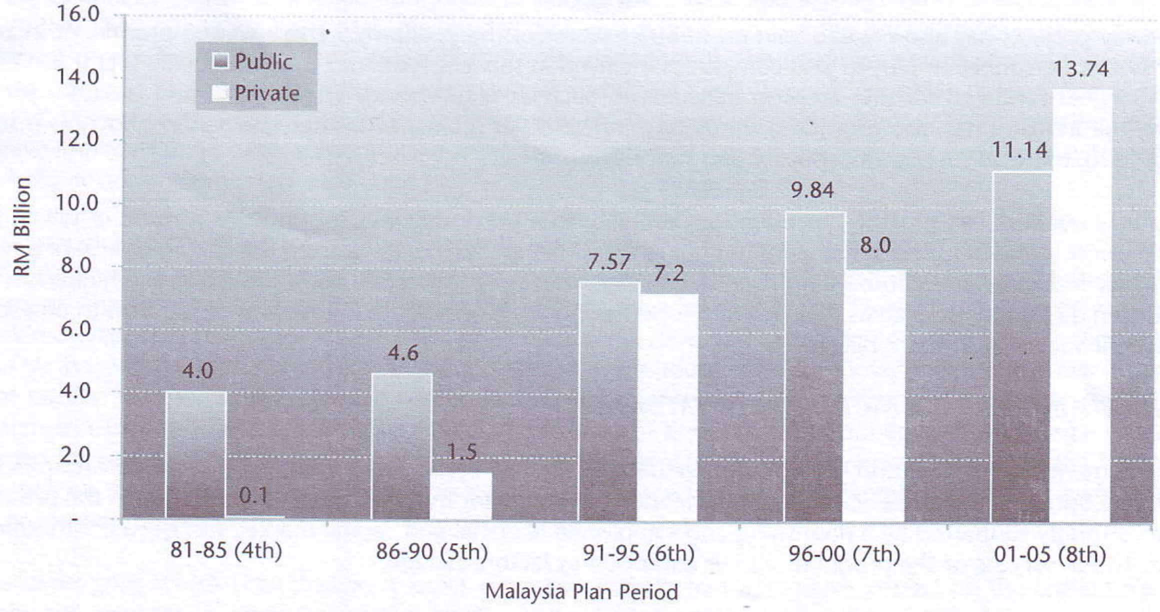

Figure 4: Investment in Road Development

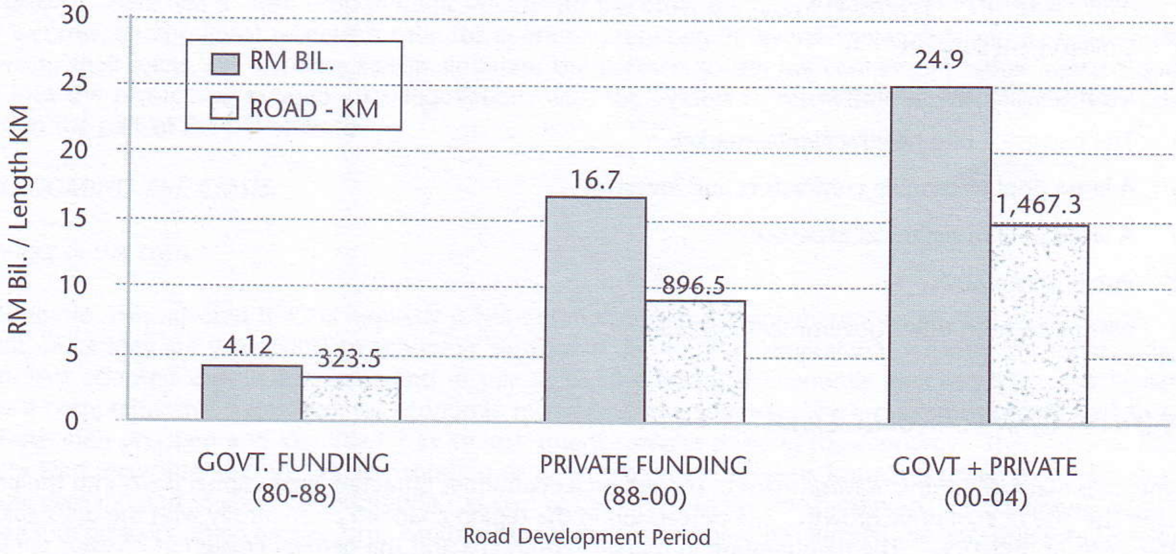

Figure 5: Government and Private Sector Investment in Toll Highway Privatisation

6.4 Innovation and greater economic activities

As privatised entities, the private sector is profit motivated and more flexible in pursuing corporate expansion goals. They are also innovative to ensure construction costs are maintained at optimum levels and also in promoting services that are previously unknown and which have commercial value. The economy thus gained from increased private sector efficiency, utilisation of gains for further expansion and an enhanced rate of infrastructure project implementation. It has thus led to the promotion of greater economic activities down stream. Other benefits include the following:

- The development of a matured capital market and investment instruments. A number of privatised road entities, through their parent holding companies, were listed on the Kuala Lumpur Stock Exchange.
- Earlier implementation and completion of viable highway projects.
- Cost saving innovations in construction techniques.
- Users enjoy an improved standard of service and greater accessibility.
- The creation of more job opportunities.
- The development of various areas of expertise in the local highway industry.

6.5 Other spill-over effects

Toll highway projects has also created spin-off in other sector of the economy. There were a prominent increase in the number of personnel employed and companies involved in services rendered to the highway sector as described earlier. Services rendered include areas in consultancy such as engineering, architectural and quantity surveyors. However, the industry has also promoted the flourishing of other related industries and services such as insurance, banking, food, material supplies, hospitality and tourism.

The highway network has provided increased accessibility that previously was missing. As a result of which we see township projects and industrial areas sprouted out in areas that are further away from the circumference of developed areas. Major industrial areas amounting to a few hundred hectares each were common along the highways. There were a dozen major township areas that had developed along the North South Expressway corridor, with on estimated development valued at RM23.2 billion.

7. CONTRIBUTING SUCCESS FACTORS IN PRIVATISATION

The Government's promotion and growth of privatisation can only come about with a conducive environment for its healthy development. The presence of a well developed private sector that has actively participated in the privatisation program, strongly supported by a flourishing and established financial and capital market, has been contributing vital elements to the success of the program. Other contributing factors include:

a) Government's commitment
b) Ideal investment atmosphere
c) Government support
d) Clear policies and guidelines
e) The existence of a healthy capital market
f) A large pool of capable contractors and investors
g) A large pool of technical expertise
h) Public acceptability
i) Assistance from other government agencies.

8. EFFECTS OF ASIAN ECONOMIC CRISIS

The favourable macroeconomic environment in the regional economies attracted large capital flows into the country, enhancing the rate of economic growth. The perception in the region changed dramatically with the outbreak of the economic crisis in mid-1997. The deterioration in market sentiments and the general erosion in investor confidence triggered a massive outflow of short-term capital. Reductions in the value of regional currencies and stock markets soon followed. The crisis adversely affected the Malaysian economy, resulting in a weakened financial sector. The collapse of the stock market seriously constrained the ability of the corporate sector to procure financing through the stock market. These factors, plus the curbing on credit growth in the early period of the crisis and the lack of confidence among other factors, caused a big decline in private investment.

The severe liquidity problem and reduced accessibility to credit affected the performance of the toll concession companies and denied the toll concession holders the much needed funding for the implementation of new highway projects. The economic crisis that hit the East Asian region adversely affected the highway privatisation program. A total of 13 toll highway concessions in the construction phase were affected by the crisis and only three managed to complete their projects by early 1999, as these projects were already nearing completion. One project was completed by the end of 2000 after encountering some delays, whilst seven projects were unable to commence construction works due to the unavailability of funding. The Government and toll concession holders who had recently been awarded privatised highway projects faced some trying times between 2000 and 2003. Great efforts were made by all the parties concerned to procure financing for the projects. As a remedial step, the Government reviewed the planned toll highway projects to ensure that only viable and priority projects were given approval. As a result, the Government decided to put on hold more than ten privatised toll highway projects, totalling approximately 1000 km.

There were other issues arising from the crisis that had an effect on the country. Toll highway concession companies that were unable to commence construction works created problems which affected both the Government and the

public. Existing roads that were transferred to the concession companies were unable to have the desirable level of maintenance applied to them. The Authority had to pursue the matter aggressively with the concession companies to ensure that their obligation were met; meanwhile motorists have to endure the poor condition of the roads. The Government proceeded with the land acquisition process even though the commencement of works was uncertain, as further delays in its acquisition would have incurred additional costs through increases in the price of land and subsequent project costs. Additionally, the act of freezing the highway corridors without their impending acquisition could have impeded other development plans along the corridors or caused speculation if the highway projects were put on hold or not implemented later on.

Public acceptance of privatised toll highway projects was manifested in the economic crisis especially with regards to the toll rate level. User complaints on the level of toll rates or rate of increase, became more frequent. The Government subsequently took action to defer toll rate increases or reduce the level of toll charges as a result of feedback received. Toll rate increases were not implemented in 1998 and prevailing toll rates for new highways were reduced by as much as 33%. Even though these measures were adopted by the Government and it has lessened the financial burden on the highway user, it has financial implications as the Government had to compensate the toll concessionaires for the lost in toll revenue. As a spill over from the above, the public and other organisations also questioned the implementation of new toll highway projects. As a result, the Government has decided that a public opinion poll on the projects will have to be carried out first to ascertain public acceptability and the level of toll rates on the proposed highways.

The economic crisis which brought about lower economic activity had a negative impact on the traffic volumes for the main toll concession operator of the North South Expressway and the Penang Bridge crossing in 1998. Meanwhile, there were mixed results in 1999 in that, while some toll highway projects had began to show a positive traffic growth, there was a slight drop in traffic volume for the other toll highway projects. The lower traffic volumes meant a corresponding lower revenue for the toll operators, resulting in several operators facing a cash-flow problem in servicing their loans. In response to this situation, the partners in the toll concessions either injected additional equity into the projects or entered into negotiations with the lenders to reschedule loans repayment to prevent a default on the part of the toll operators.

9. OVERCOMING THE CRISIS

9.1 Impact of the crisis

The economic crisis affected the toll highway privatisation program as implementation of new projects almost come to a halt, since they are susceptible to economic slowdown due to their requirement for a huge capital outlay. The Government adopted various measures and in July 1998, the National Economic Recovery Plan was launched to provide a comprehensive framework for economic recovery in the country. The Government continued to support the privatisation program and identified it as an instrument towards reviving the economy. The National Economic Recovery Plan recommended the implementation or priority highway projects including urban highways to provide for future demand and to alleviate congestion. As part of the efforts to provide funding to the companies undertaking infrastructure projects which require large capital outlays, the Government has formed the Infrastructure Development Bank.

The establishment of the Infrastructure Development Bank saw initial funding of RM5 billion allocated to assist in the financing of infrastructure projects and projects involving large public facilities such as highways, mass transit rail transportation, ports, water supply projects, etc. The aim of the fund was to facilitate the implementation of priority infrastructure projects and to revive stalled highway projects. In addition, as well as fulfilling its economic and social obligations, the Government has initiated the commencement of construction of the strategic 338 km long East Coast Expressway (ECE), an interurban expressway that will connect the more developed west coast States of Peninsula Malaysia to the less developed east coast States.

9.2 Steps taken to overcome the crisis

The Government adopted a flexible approach and held numerous meetings with the concession holders to exchange ideas on measures to adopt to enable the remaining toll highway projects to kick start the construction works. For example, the implementation of the East Coast Expressway was initially a privatised project due to commence in 1999 but, as a result of the economic slowdown, the concession company was unable to raise sufficient finance and this prompted the Government to buy back the project using public funds. The Government's action has managed to kick start the project and the first phase of the expressway (169 km long) was completed in July 2004. The Government is about to embark on the second phase for the remaining length. That same year also saw three other privatised highways, which had been stalled during the economic crisis, completed.

Other steps taken by the Government to facilitate the process included amending the concession agreements to allow for:

- reduction of the scope of works in the contract to improve project viability
- rescheduling of the construction program to allow for phase construction of viable stretches first and extension of the construction period
- stage construction of the highway and upgrading of lanes to be carried out based on traffic demand
- defer construction of interchanges which have low traffic flows or lower demand
- combining financing packages using Government grants or loans to improve the viability and bankability of the project.

Concession holders have on their own also taken various steps and measures to strengthen their companies and improve project viability. This includes increasing equity contributions from the partners and restructuring the shareholding structure by bringing in partners with strong financial backing into the consortium. In addition, to factor in the effects of the crisis, a more updated independent traffic study was conducted to assure the lenders that the project was still financially viable. As a result, two privatised toll highway projects were able to start construction works towards the later part of 1999, together with the assistance extended to them by the Infrastructure Development Bank.

In the meantime, positive signs have become apparent which augur well for the industry's future. On the other fronts, the Government undertook measures to strengthen the resilience of the financial sector to avoid systemic risk and ensure the continued efficient functioning of the role of the banking system crucial for the economic recovery. Complementary actions were taken such as the establishment of a new Government vehicle, 'Danaharta' and 'Danamodal', to put the banking institutions on a strong footing by purchasing and managing the non-performing loans and recapitalising the banking institutions. The banking sector still plays a major role in managing and providing the necessary funding for toll highway projects. In response to the financial crisis, the Kuala Lumpur Stock Exchange has also implemented measures aimed at ensuring systemic stability, by restoring market confidence, improving market transparency and corporate governance and facilitating the raising of funds.

Whilst the benefits of privatisation were very high, the Government has reviewed certain policies and guidelines in the privatisation of highway projects, by tightening certain terms and conditions. Toll rate increases are no longer automatic and toll concession companies have to justify any increases. For new toll highway project proposals, the proponents of the project will have to demonstrate that the project is financially viable and be able to convince the lenders to extend financial support for the project.

10. ASSESSMENT OF HIGHWAY PRIVATISATION PROJECTS

Based on the experience from previous highway privatisation projects, a number of lessons have been obtained. These could be useful for future implementation of projects under privatisation.

10.1 Cross-subsidisation

Projects of adequate size and/or with existing operational sections allow for the more lucrative sections to subsidise the low revenue-generating sections. Such cross-subsidisation potential is a major factor in determining the success of a privatised highway, as observed from the NSE, the Damansara-Puchong Highway and the Western Kuala Lumpur Traffic Dispersal Scheme. Concession companies that undertaken road projects without such potential are more prone to facing difficulties in debt-servicing, for example the Malaysia Singapore Second Crossing and the Seremban-Port Dickson Highway.

10.2 Social obligations versus profitability

With privatisation, social services that were initially managed by the Authorities became business ventures. Although the two objectives – social service and profit-making – can, with appropriate measures, be mutually achieved, more studies are needed into the prerequisite parameters that will ensure an acceptable balance between greater profitability for the company and better services at lower costs for the public.

10.3 Variations to certain established fundamentals

The country is developing physically and these developments have impacted, directly or indirectly, on privatised projects. In the case of the NSE, the completion of the project resulted in a tremendous proliferation of industrial and

housing development along the highway, which in turn resulted in numerous requests for access to the highway. Whilst this growth in future traffic along the highway is a welcome development, certain engineering and design guidelines will need to be modified.

For example, certain concessions have been made with respect to the minimum spacing between interchanges along the NSE to accommodate requests for access to some of these developments. If these spacings are further reduced in the coming years, the expressway may eventually function as a 'main street' within the development corridor. With respect to drainage aspects, a major portion of the NSE was designed based on rural standards. Such provisions are not able to meet the demands associated with the rapid development that has been taking place at certain locations upstream of the Expressway, resulting in flooding of the expressway.

In view of these considerations, a co-ordinating body may need to be established to rationalise the various State Governments who approve and monitor these developments, taking into consideration the main objective of an expressway.

10.4 Competition

Although no exclusivity is given to the concession companies, the approval for the construction of parallel roads adjacent to their corridor is of great concern. The introduction of competing routes, which may not have been foreseen during the feasibility study stage, will definitely impact on their financial viability. Such changes in the parameters governing privatised projects can have serious consequences on the existing concessions.

10.5 Improvements to concession agreement

Since the inception of the privatisation concept, the Government has continuously made an effort to improve the terms and conditions of each subsequent Concession Agreement. More emphasis needs to be placed on these efforts in order that more comprehensive terms and conditions for future concessions, which will benefit the public, are established.

10.6 Impact of global economy

The global economy has a direct impact on the performance of privatised highways. A global economic downturn, as experienced in 1998, would render the assumptions made during the viability assessment stage invalid. Based on the Malaysian experience, this has resulted in negative financial implications due to the lower rate of development and traffic growth (for example the Malaysia Singapore Second Crossing and Seremban-Port Dickson Highway) as well as the delay in the progress of on-going projects (for example the Kajang-Seremban Highway) and the commencement of planned projects (for example the KL-KLIA Dedicated Highway and the Assam Jawa-Templer Park Highway).

11. CONCLUSION

This paper has briefly described the road privatisation mechanism, the approach adopted, lessons learnt in previous years and how the recent Asian economic crisis affected the implementation of road privatisation projects. Malaysia has achieved good progress with the privatisation program which has succeeded in its objectives in promoting greater economic growth and development. The private sector has been the main party in the implementation of toll highway projects in Malaysia and it has also contributed to the development of other related industries in the country such as financial, construction and technical services, etc. Although the toll highway program has been affected by the economic crisis, the Government has provided strong support and adopted various measures to ensure that the program is back on the right path. In view of the benefits gained, the Government has continued with the privatisation policy as one of its measures to revive and play the catalytic role of accelerating economic recovery. In this respect, the Government has reviewed and make adjustment to certain policies to address and cope with the problems faced by the toll highway concessionaires, to ensure the continued success of the highway privatisation program.

DEVELOPMENT OF HOURLY, DAILY AND MONTHLY FACTORS AND ITS APPLICATION TO PREDICTION MODEL FOR MOTORCYCLE ACCIDENTS AT JUNCTIONS IN MALAYSIA

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ABSTRACT

This paper describes the development of hourly, daily and monthly factors representing volume-variation patterns of traffic in typical States in Malaysia. A simple and quick method for the estimation of the Annual Average daily Traffic (AADT), based on short traffic counts using the appropriate conversion factors of hourly traffic volume, is presented. Also presented is an application of this technique in the development of a prediction model for motorcycle accidents at non-signalised junctions in Malaysia. One of the most important variables included in the model is the AADT estimated using the factors developed during the study. The model, which was developed using the generalised linear modelling approach and the quasi likelihood technique, was incorporated to overcome the dispersion problem. The model suggested that an increase in AADT on major and minor roads was associated with an increase in motorcycle accidents, and the AADT on major roads had the greater effect on the probability of motorcycle accidents than the AADT on minor roads. Shoulder width was also found to be significant in explaining motorcycle accidents. The final model should allow traffic engineers to establish appropriate junction treatments specifically designed for motorcycle lane facilities at junctions.

1. INTRODUCTION

Many studies on traffic accident modelling found that traffic flow is one of the significant factors in affecting accidents (e.g. Bauer and Harwood 2000; Griebe and Nielsen 1996; Mountain, Fawaz and Jarret 1996; Mountain, Maher, and Fawaz, 1998; Radin Umar 1996; Radin Umar, Mackay and Hills 1995 and 2000; Saied, and Said 2001; Tarko et al. 1999; Taylor, Baruya and Kennedy 2002; Vogt and Bared 1998; Vogt 1999). Most of these studies used Annual Average Daily Traffic (AADT) to represent traffic flow. The AADT used in the analysis was usually collected from permanent stations at specific locations within the study area. When such information was not available, the AADT was estimated by converting traffic volume, usually hourly volume collected at the site using hourly, daily and monthly factors. Earlier studies on accident modeling carried out in UK (Mountain et al. 1996 and 1998) used such factors to convert traffic volume, obtained during a short counting period, to AADT. A similar approach has also been used in previous studies conducted in the USA (Bauer and Harwood 2000; Vogt and Bared 1998; Vogt 1999). As such factors have not yet been developed in Malaysia, there was a need to develop factors so that AADT could be estimated more accurately.

This paper describes the development of hourly, daily and monthly factors representing volume-variation patterns of traffic in the State of Selangor and the Federal Territory of Kuala Lumpur. The paper also describes the development of a model for the prediction of motorcycle accidents at non-signalised junctions on urban roads where the AADT estimated using the factors developed in this study was included as one of the variables in the model. The generalised linear modeling approach (McCullagh and Nelder 1989) was used to develop the model, and the Poisson and negative binomial errors were incorporated to represent observed accident distribution. The statistical software package, GLIM 4 (Numerical Algorithm Group 1994), which is specially designed to fit generalised linear models, was used in the statistical analysis.

2. MATERIAL AND METHODS

2.1 Hourly, daily and monthly factors

Nine districts of the State of Selangor and the Federal Territory of Kuala Lumpur were selected for the study. The factors representing the volume-variation patterns of traffic in the selected districts were developed using the data

compiled from the 24-hour permanent traffic count station and the traffic census (Highway Planning Unit 2001a and b). The permanent count station considered the most appropriate to represent the variation of traffic in the selected districts was the PS-07. This station was located between Kuala Lumpur and Seremban.

Figure 1 presents the framework for the development of hourly, daily and monthly factors including the estimation of AADT. As shown in the Figure, the data collected at permanent count station PS-07 was used to develop daily and monthly factors. It should be noted that the station only recorded those vehicles categorised as light, medium and heavy vehicles. This meant that the data can only be used to develop daily and monthly factors for those vehicle categories or, by combining the data, for all vehicles. The data recorded in the non-permanent count station (traffic census) were used to develop the hourly factors. This data was classified into several vehicle categories, including motorcycles. As a result, hourly factors were developed for both non-motorcycles and motorcycles.

Records of hourly traffic (disaggregated into non-motorcycles and motorcycles) counted on major and minor roads at the selected junctions were converted to AADT using the factors developed in this study. The technique described in McShane, Roess and Prasas (1998) including a detailed procedure and examples on how to develop the factors and use them to convert short-count traffic volume to AADT, was used to carry out the work.

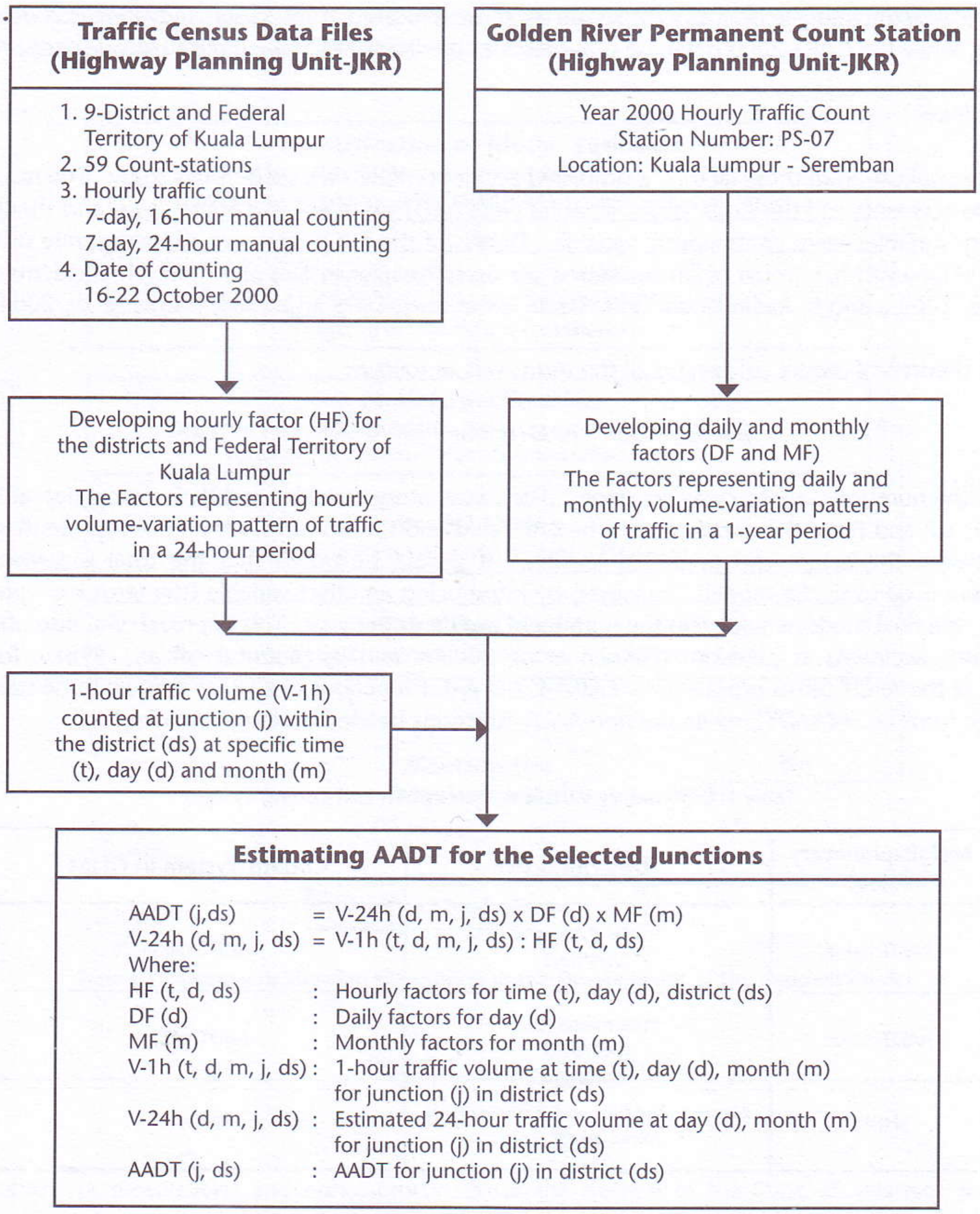

Figure 1: Framework for the Development of Hourly, Daily and Monthly Factors, and the Estimation of AADT

2.2 Selected junctions and motorcycle accident data

The junctions were selected based on several criteria, e.g. they had only marginal change of land use with no major modification or upgrading; there was an equal number of lanes on the corresponding approach of the major and minor roads; and there was no access road within 50 metres from the junction Stop line. It should be noted that only those junctions with a history of Personal Injury Accident (PIA) statistics were included in the analysis. Junction accidents involving motorcycles were defined as any motorcycle accident occurring within 50 metres of the corresponding Stop line of the junction.

Data on motorcycle accidents, AADT and shoulder width of the 53 randomly selected junctions on urban roads in the four districts (Hulu Langat, Klang, Kuala Langat and Petaling) of the State of Selangor were collected and analysed in the study. Motorcycle accident data over a four-year period (1997-2000) was procured from the archives of the police accident recording forms, POL 27 (Pin 1/91). The POL 27 is specially designed for easy completion (Radin Umar et al. 1993) and is fully compatible with the TRL's Microcomputer Accident Analysis Package, the MAAP (Hills and Baguley 1993). The data was extracted from two complementary sources: (1) the Microcomputer Accident Analysis Package (MAAP) database for fatal and hospitalised accidents, and (2) the Computerized Accident Recording System (CARS-2000) database for slight injury accidents. The MAAP database is located at the Road Safety Research Center, Universiti Putra Malaysia, while the CARS-2000 database is available at the Royal Malaysian Police Headquarters.

2.3 Accident Model

To illustrate the application of these factors, a simplified accident model was used in this study. The response variable was motorcycle accidents and the explanatory variables were AADT on major and minor roads and shoulder width; all the explanatory variables were continuously variable. Details of the full models which incorporate other geometric variables such as lane width, number of lanes and land use used in earlier studies of motorcycle accidents are contained in Harnen et al. 2003 a and b; Radin Umar 1996; Radin Umar et al. 1995 and 2000; Harnen et al. 2004.

The simplified theoretical model containing all the terms was as follows:

$$MCA = k\ AADTmajor^{\alpha 1}\ AADTminor^{\alpha 2}\ EXP^{(\beta SHDW + e)} \qquad (1)$$

where MCA is the number of motorcycle accidents. The explanatory variables and their description are presented in Table 1. k, $\alpha 1$, $\alpha 2$ and β are the parameters to be estimated and the (e) term is the error representing the residual difference between the actual and predicted models. It should be noted that the total four-year (t) accident frequencies were used to fit the models. However, by introducing an offset variable (the term log t period) into the fitting process, the final model would yield the number of accidents per year. This approach was also utilised in earlier studies on traffic accidents at junctions (Harnen et al. 2003 a and b; Mountain et al. 1998). To allow direct interpretation of the AADT terms produced by GLIM 4, the AADT functions in eqn (1) needed to be transformed into the logarithmic form i.e. ln(AADT), while the non-AADT functions needed no transformation.

Table 1: Explanatory Variables, Description and Coding System

MalaExplanatory Values	Description	Coding System in GLIM
AADTmajor	major road flow (veh/day)	AADTmajor
AADTminor	minor road flow (veh/day)	AADTminor
SHDW	average shoulder width on major & minor roads (m)	SHDW

The Poisson and Negative binomial errors were considered in the study, and the method suggested in earlier analysis (Harnen et al. 2003 a and b) was adopted to justify the error distribution used for statistical analysis. The choice of error distribution was based on the goodness-of-fit test carried out on the observed accident frequencies under study. The deviance was used as a measure of the goodness-of-fit (Numerical Algorithm Group 1994) and the minimum

deviance generated in the fitting process was considered, as the theoretical frequencies being analysed were the closest fit to the observed accident frequencies. In addition, a hypothesis test at 95% confidence level ($p<0.05$) was carried out on the selected distribution.

The quasi-likelihood approach (McCullagh and Nelder 1989; Numerical Algorithm Group 1994) was used to overcome the dispersion problem, as this approach had been usefully employed in earlier studies on motorcycle accidents (Harnen et al. 2003a and b; Radin Umar 1986; Radin Umar et al. 1995 and 1996). In this technique, the dispersion parameter was estimated from the mean deviance (scaled deviance over its degrees of freedom). This may form a model where the scaled deviance is equal to its degrees of freedom.

The model was developed on the basis of multivariate analysis. This analysis allows which of the variable(s) had the highest effect on the probability of motorcycle accidents to be assessed. The fitted model was based on the goodness-of-fit and the significance test carried out. They are the change in scaled deviance from adding or removing the terms, the ratio of scaled deviance to its degrees of freedom and the 5% significance level of the t-statistic of the parameter estimates. The framework showing the process of the development of the accident model is presented in Figure 2. Since the fitted model satisfied the requirements, the analysis produced the final model; otherwise, the process would have had to return to the model specification, with one of its components, e.g. explanatory variables, having to be re-identified. This is the usual process used in developing a model.

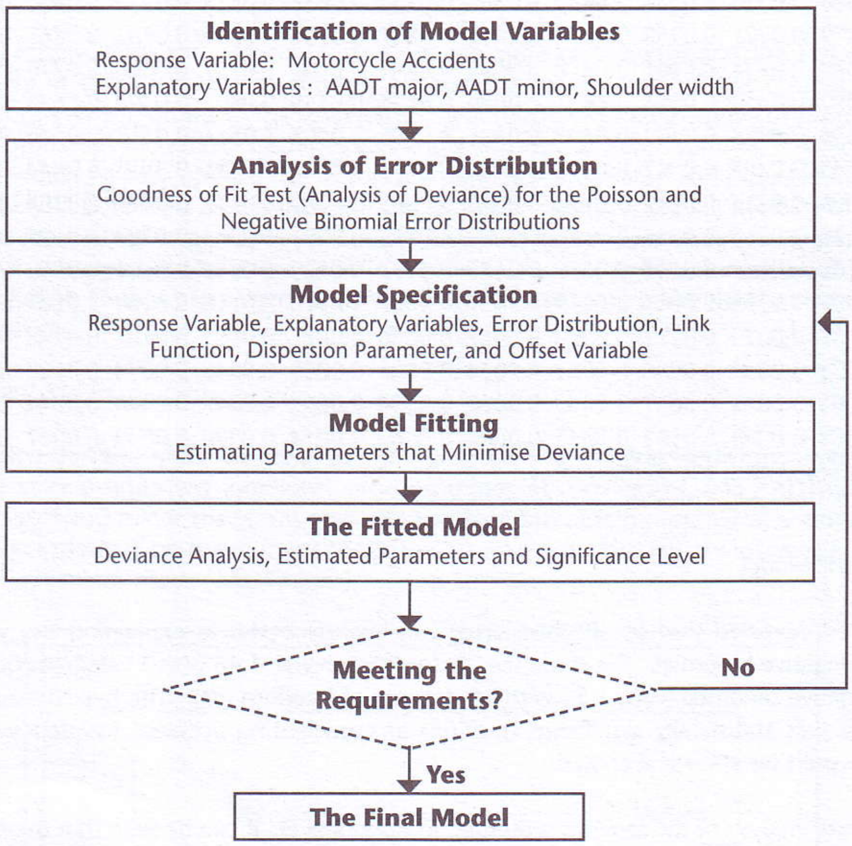

Figure 2: Framework Showing the Process of the Development of the Accident Model

3. RESULTS

3.1 Factors

The hourly factors for motorcycles and non-motorcycles for the districts of the State of Selangor and the Federal Territory of Kuala Lumpur were established. The non-motorcycle and motorcycle factors of the District of Hulu Langat (Table 2) were based on continuous hourly counts of traffic recorded in the non-permanent count stations BR604, BR605, BR608, BR609 and BR614 for a period of one week. The factors represent hourly volume-variation patterns of traffic in a 24-hour period within the district of Hulu Langat.

The hourly traffic factors for the other districts and the Federal Territory of Kuala Lumpur and the daily and monthly factors for all vehicles are presented in Appendices A and B. An example of the calculation of AADT for motorcycles on major and minor roads of the three-legged non-signalised junctions using the factors developed in this study is shown in Appendix C.

Table 2: Hourly Factors for Non-Motorcycles and Motorcycles (District of Hulu Langat)

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0368	0.0771	0.0388	0.0481	0.0351	0.0342	0.0339	0.0481	0.0383	0.0270	0.0251	0.0345
0700-0800	0.0692	0.1214	0.0713	0.1394	0.0712	0.1000	0.0728	0.1138	0.0673	0.0923	0.0563	0.0841
0800-0900	0.0696	0.0768	0.0712	0.0746	0.0709	0.0868	0.0609	0.0625	0.0713	0.0717	0.0527	0.0478
0900-1000	0.0521	0.0430	0.0545	0.0390	0.0562	0.0502	0.0478	0.0436	0.0498	0.0403	0.0486	0.0431
1000-1100	0.0539	0.0454	0.0505	0.0400	0.0526	0.0523	0.0516	0.0491	0.0530	0.0457	0.0524	0.0484
1100-1200	0.0606	0.0429	0.0477	0.0437	0.0484	0.0424	0.0473	0.0408	0.0485	0.0441	0.0501	0.0430
1200-1300	0.0525	0.0535	0.0484	0.0488	0.0500	0.0403	0.0559	0.0391	0.0518	0.0444	0.0461	0.0452
1300-1400	0.0572	0.0437	0.0462	0.0475	0.0468	0.0350	0.0550	0.0361	0.0535	0.0451	0.0533	0.0442
1400-1500	0.0665	0.0415	0.0557	0.0482	0.0543	0.0436	0.0552	0.0406	0.0502	0.0508	0.0492	0.0450
1500-1600	0.0560	0.0382	0.0496	0.0460	0.0550	0.0470	0.0571	0.0432	0.0536	0.0429	0.0605	0.0446
1600-1700	0.0566	0.0516	0.0541	0.0442	0.0567	0.0523	0.0636	0.0614	0.0525	0.0460	0.0568	0.0527
1700-1800	0.0679	0.0771	0.0748	0.0857	0.0651	0.0827	0.0605	0.0835	0.0641	0.0863	0.0645	0.0811
1800-1900	0.0648	0.0751	0.0661	0.0678	0.0685	0.0849	0.0649	0.0797	0.0606	0.0779	0.0654	0.0827
1900-2000	0.0482	0.0452	0.0586	0.0631	0.0649	0.0675	0.0559	0.0605	0.0574	0.0675	0.0543	0.0505
2000-2100	0.0396	0.0388	0.0502	0.0503	0.0521	0.0495	0.0508	0.0516	0.0558	0.0546	0.0539	0.0620
2100-2200	0.0363	0.0295	0.0382	0.0355	0.0434	0.0391	0.0412	0.0381	0.0435	0.0444	0.0467	0.0443
2200-2300	0.0398	0.0316	0.0289	0.0196	0.0345	0.0265	0.0439	0.0252	0.0342	0.0304	0.0510	0.0307
2300-2400	0.0276	0.0215	0.0256	0.0166	0.0239	0.0176	0.0281	0.0244	0.0289	0.0139	0.0406	0.0182
0000-0100	0.0162	0.0159	0.0137	0.0119	0.0145	0.0193	0.0190	0.0249	0.0275	0.0202	0.0213	0.0306
0100-0200	0.0069	0.0093	0.0084	0.0079	0.0081	0.0081	0.0116	0.0118	0.0108	0.0167	0.0136	0.0219
0200-0300	0.0037	0.0070	0.0171	0.0060	0.0067	0.0076	0.0077	0.0105	0.0107	0.0148	0.0126	0.0203
0300-0400	0.0033	0.0049	0.0046	0.0051	0.0054	0.0035	0.0060	0.0046	0.0074	0.0120	0.0107	0.0141
0400-0500	0.0064	0.0042	0.0067	0.0043	0.0068	0.0034	0.0051	0.0049	0.0044	0.0044	0.0086	0.0058
0500-0600	0.0083	0.0049	0.0192	0.0067	0.0089	0.0062	0.0044	0.0020	0.0050	0.0067	0.0060	0.0052

Non-Mc: Non-motorcycles; Mc: Motorcycles

3.2 Motorcycle Accident Model

The goodness-of-fit test revealed that the Poisson error was slightly better in explaining the variation of accident occurrence than the Negative binomial. The deviance (D) for Poisson was 4.46 with 11 degrees of freedom (df), whilst the values for the Negative binomial were 4.52 with 10 degrees of freedom (df). The hypotheses test also confirmed that the Poisson error was statistically significant ($p<0.05$) in representing accident frequencies under study. The Poisson was therefore used for statistical analysis.

The result of multivariate analysis of the terms is presented in Appendix D. It can be seen that the explanatory variables were significant at the 5% level. The scaled deviance was equal to the degrees of freedom, as the quasi-likelihood approach had been introduced in the fitting process. The scaled deviance changed from 3,112.0 to 49.0 with a loss of 3 degrees of freedom, and the mean deviance changed from 59.8 to 1.0.

Based on multivariate analysis, the final model developed in this study is:

$$MCA = 0.0006039\ AADTmajor^{0.5369}\ AADTminor^{0.2869}\ EXP^{-0.0864\ SHDW} \qquad (2)$$

where MCA is the number of motorcycle accidents per year. Figure 3 shows the standardised residual of the modelled accidents over the actual accidents. It can be seen that the standardised residuals was well within the value of -2.0 and +2.0. This is the acceptable range of standardised residual for a well-fitting model (Numerical Algorithm Group 1994).

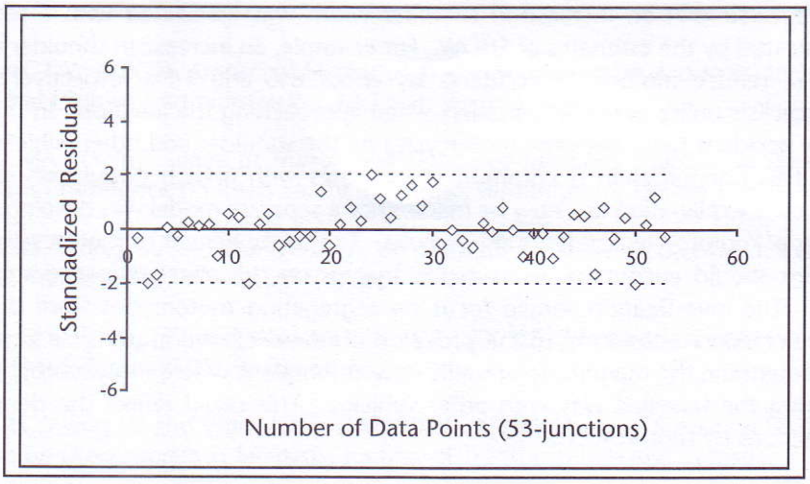

Figure 3: Values of Standardised Residual

4. DISCUSSION

4.1 The Factors

The study developed hourly, daily and monthly factors for the State of Selangor and the Federal Territory of Kuala Lumpur. The reliability of these factors was strongly affected by the accuracy of the estimation of AADT, and its availability was therefore very important to the researchers. It is suggested that a study covering the entire country is conducted. As the automated recording machines can easily record the traffic volume, the factors can be updated from time to time. It would be very useful if the factors are periodically updated and included in publications such as the Traffic Volume Malaysia published annually by the Highway Planning Unit (HPU), Ministry of Works, Malaysia. In addition, the vehicles recorded at the permanent count stations in Malaysia were roughly categorised as light, medium and heavy. As such, it is suggested that more specific vehicle categories, such as lorries, buses, passenger cars and motorcycles, be established, so that more specific daily and monthly factors can be determined rather than just light, medium and heavy vehicles.

4.2 Motorcycle Accident Model

The final model revealed that the AADT on major and minor roads and shoulder width were significant in explaining motorcycle accidents at non-signalised junctions. The estimates of AADTmajor and AADTminor indicate that an increase in AADT on major and minor roads was associated with an increase in motorcycle accidents (Figure 4). It was also found that the effect of AADT on major roads (AADTmajor) on the probability of motorcycle accidents was higher than that of the AADT on minor roads (AADTminor).

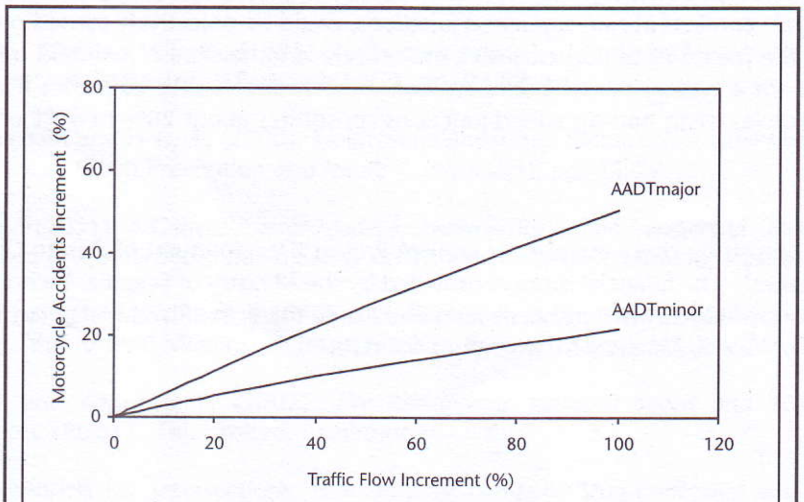

Figure 4: Effect of Traffic Flow on Motorcycle Accidents

The final model also revealed that an increase in shoulder width was associated with a reduction in motorcycle accidents. This was indicated by the estimates of SHDW. For example, an increase in shoulder width by 1 metres and 2 metres is expected to reduce motorcycle accidents by about 8% and 16% respectively. This finding seems reasonable since motorcyclists utilise available shoulders when approaching the junction. In this situation, the rate of rear-end and side-swipe accident types between motorcycles on the shoulder and other vehicles on the travelled way is probably reduced. This phenomenon is common in countries with a high population of motorcycles such as Malaysia. However, a better explanation can now be made since a separate model was developed to explain the effect of shoulders on all types of motorcycle accidents at junctions. The safety benefit to motorcyclists from the availability of shoulders at junctions should encourage an in-depth analysis on the effect of paved shoulders on motorcycle accidents at junctions. The investigation should focus on segregating motorcycles from other, larger vehicles at junctions. The initiative could take the form of the provision of non-exclusive motorcycle lane facilities at junctions. It is also imperative to determine the magnitude of traffic flow at junctions where most motorcyclists use shoulders for riding rather than sharing the travelled way with other vehicles. This could reflect the demand for non-exclusive motorcycle lanes at junctions by motorcyclists.

5. CONCLUDING REMARKS

This paper has described the development of hourly, daily and monthly factors representing volume-variation patterns of traffic in the State of Selangor and the Federal Territory of Kuala Lumpur. The paper has also described the development of a model for the prediction of motorcycle accidents at non-signalised junctions on urban roads where the AADT estimated using the factors developed in this study was included as one of the variables in the model. The main findings of the study were as follows.

1. The hourly, daily and monthly factors, which represent the volume-variation patterns of traffic, could change from time to time depending on the changes on the magnitude of traffic flow. The factors should therefore be updated periodically (at least every year) so that the appropriate factors could be established and a more accurate AADT estimated. The factors should also be included in the related publications in Malaysia so they can be distributed nationally. A national study is also suggested.

2. AADT is important variable in explaining motorcycle accidents at non-signalised junctions. An increase in AADT on major and minor roads at non-signalised junctions was associated with an increase in motorcycle accidents. The effect of AADT on major roads on the probability of motorcycle accidents was higher than that for minor roads. Shoulder width at non-signalised junctions was also found to be significant in explaining motorcycle accidents. Wider shoulders are associated with a reduction in motorcycle accidents.

3. The model developed in this study can further be utilised to determine the appropriate intervention levels for junction treatment with respect to motorcycle accidents. For a given acceptable limit of motorcycle accidents, appropriate design parameters for non-signalised junctions could be specified. The decision whether to allow motorcycles to pass through a non-signalised junction without treatment, or the need for special end-treatments to minimise motorcycle conflicts at non-signalised junctions, could be objectively carried out using the model; the treatment could be the provision of non-exclusive motorcycle lanes facilities. It should be noted that the model might only be valid for a typical mixed traffic environment in developing countries like Malaysia, where the proportion of motorcycles using non-signalised junctions constitutes about 20% to 40% of all vehicles.

ACKNOWLEDGMENTS

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REFERENCES

Bauer, KM and Harwood, DW (2000). *Statistical Models of At-Grade Intersection Accidents-Addendum.* Publication No. FHWA-RD-99-094. Federal Highway Administration, McLean, Virginia, USA.

Griebe, P and Nielsen, MA (1996). *Safety at Four-Armed Signalized Junctions Situated on Roads With Different Speed Limits.* Proceedings of the Conference on Road Safety in Europe, Birmingham, United Kingdom, pp. 151-63.

Harnen, S, Radin Umar, RS, Wong, SV and Wan Hashim, WI (2003a). *Predictive Models for Motorcycle Accidents at Three-Legged Priority Junctions.* Traffic Injury Prevention 4(4), pp. 363-69.

Harnen, S, Radin Umar, RS, Wong, SV and Wan Hashim, WI (2003b). *Motorcycle Crashes Prediction Model for Non-Signalized Intersections.* IATSS Research 27(2), pp. 58-65.

Harnen S, Radin Umar RS, Wong SV and Wan Hashim WI (2004). *Development of Prediction Models for Motorcycle Crash at Signalized Intersection on Urban Roads in Malaysia.* Journal of Transportation and Statistics 7(2/3).

Highway Planning Unit (2001a). *Golden River Permanent Count Station. Annual Report*, Ministry of Works, Malaysia.

Highway Planning Unit (2001b). *Traffic Volume Malaysia. Biannual Report*, Ministry of Works, Malaysia.

Hills, BL and Baguley, CJ (1993). *Accident Data Collection and Analysis: The Use of Microcomputer Package MAAP in Five Asian Countries.* Proceedings of the Conference on Asian Road Safety (CARS'93), Kuala Lumpur, Malaysia, pp. (4-16)-(4-31).

McCullagh, P and Nelder, JA (1989). *Generalized Linear Models. 2nd Edition.* Chapman and Hall.

McShane, WR, Roess, RP and Prasas, ES (1998). *Traffic Engineering. 2nd Edition.* Prentice Hall, New Jersey.

Mountain, L, Fawaz, B and Jarret, D (1996). *Accident Prediction Models for Roads with Minor Junctions.* Accident Analysis and Prevention 28(6), pp. 695-707.

Mountain, L, Maher, M and Fawaz, B (1998). *The Influence of Trend on Estimates of Accidents at Junctions.* Accident Analysis and Prevention 30(5), pp. 641-49.

Numerical Algorithm Group (1994). *The GLIM System, Release 4 Manual.* 2nd Edition. Francis, B, Green, M, Payne, C (Eds.), Clarendon Press, Oxford.

Radin Umar, RS (1996). *Accident Diagnostic System with Special Reference to Motorcycle Accidents in Malaysia.* PhD Thesis, University of Birmingham.

Radin Umar, RS, Ahmad Rodzi, M and Aminuddin, A (1993). *Accident Diagnosis and Treatment Model in Malaysia.* Pertanika Journal Science and Technology 1(1), pp. 125-51.

Radin Umar, RS, Mackay, GM and Hills, BL (1995). *Preliminary Analysis of Exclusive Motorcycle Lanes along the Federal Highway F02 in Shah Alam, Malaysia.* IATSS Research 19(2), pp. 93-98.

Radin Umar, RS, Mackay, GM and Hills, BL (2000). *Multivariate Analysis of Motorcycle Accidents and the Effect of Exclusive Motorcycle Lanes in Malaysia.* Crash Prevention and Injury Control 2(1), pp. 11-17.

Saied, AM and Said, GM (2001). *A General Linear Model Framework for Traffic Conflicts at Uncontrolled Intersections in Greater Cairo.* Proceedings of Conference: Traffic Safety on Three Continents, Moscow, Russia.

Tarko, AP, Eranky, S, Sinha, KC and Scinteie, R (1999). *An Attempt to Develop Crash Reduction Factors Using Regression Technique.* Presented to 78th Annual Meeting of Transportation Research Board, Washington DC.

Taylor, MC, Baruya, A and Kennedy, JV (2002). *The Relationship Between Speed and Accidents on Rural Single-Carriageway Roads.* Report TRL 511, TRL Limited, Crowthorne.

Vogt, A (1999). Crash Models For Intersections: *Four-Lane by Two-Lane Stop-Controlled and Two-Lane by Two-Lane Signalized.* Report No. FHWA-RD-99-128. Federal Highway Administration, McLean, Virginia.

Vogt, A and Bared, JG (1998). *Accident Models For Two-Lane Rural Road: Segments and Intersections.* Report No. FHWA-RD-98-133. Federal Highway Administration, McLean, Virginia.

APPENDIX A

Hourly Factors for Non-Motorcycles and Motorcycles for the Districts and the Federal Territory of Kuala Lumpur

District of Klang

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0268	0.0440	0.0263	0.0471	0.0290	0.0336	0.0286	0.0411	0.0245	0.0301	0.0231	0.0332
0700-0800	0.0699	0.1294	0.0715	0.1244	0.0706	0.1112	0.0721	0.1147	0.0667	0.0989	0.0524	0.1169
0800-0900	0.0772	0.0875	0.0654	0.0759	0.0680	0.0848	0.0708	0.0912	0.0690	0.0825	0.0574	0.0625
0900-1000	0.0509	0.0342	0.0510	0.0576	0.0624	0.0589	0.0516	0.0501	0.0541	0.0596	0.0512	0.0459
1000-1100	0.0573	0.0430	0.0540	0.0426	0.0531	0.0367	0.0517	0.0332	0.0489	0.0354	0.0518	0.0443
1100-1200	0.0531	0.0436	0.0583	0.0415	0.0522	0.0438	0.0512	0.0317	0.0551	0.0387	0.0587	0.0394
1200-1300	0.0542	0.0475	0.0594	0.0432	0.0556	0.0389	0.0544	0.0395	0.0608	0.0602	0.0627	0.0441
1300-1400	0.0584	0.0419	0.0566	0.0435	0.0543	0.0518	0.0524	0.0379	0.0542	0.0419	0.0626	0.0509
1400-1500	0.0573	0.0386	0.0515	0.0486	0.0559	0.0450	0.0554	0.0406	0.0534	0.0547	0.0563	0.0498
1500-1600	0.0499	0.0392	0.0523	0.0481	0.0522	0.0413	0.0515	0.0465	0.0530	0.0341	0.0523	0.0506
1600-1700	0.0559	0.0431	0.0542	0.0445	0.0540	0.0413	0.0533	0.0436	0.0519	0.0410	0.0474	0.0468
1700-1800	0.0716	0.0883	0.0751	0.0710	0.0714	0.0888	0.0697	0.0901	0.0658	0.0771	0.0552	0.0817
1800-1900	0.0736	0.0784	0.0652	0.0691	0.0664	0.0696	0.0664	0.0766	0.0663	0.0755	0.0557	0.0604
1900-2000	0.0587	0.0714	0.0545	0.0721	0.0621	0.0790	0.0551	0.0639	0.0587	0.0586	0.0554	0.0551
2000-2100	0.0444	0.0434	0.0471	0.0516	0.0469	0.0440	0.0523	0.0553	0.0482	0.0564	0.0577	0.0424
2100-2200	0.0286	0.0273	0.0335	0.0411	0.0373	0.0391	0.0378	0.0355	0.0406	0.0362	0.0357	0.0293
2200-2300	0.0398	0.0316	0.0289	0.0196	0.0345	0.0265	0.0439	0.0252	0.0342	0.0304	0.0510	0.0307
2300-2400	0.0276	0.0215	0.0256	0.0166	0.0239	0.0176	0.0281	0.0244	0.0289	0.0139	0.0406	0.0182
0000-0100	0.0162	0.0159	0.0137	0.0119	0.0145	0.0193	0.0190	0.0249	0.0275	0.0202	0.0213	0.0306
0100-0200	0.0069	0.0093	0.0084	0.0079	0.0081	0.0081	0.0116	0.0118	0.0108	0.0167	0.0136	0.0219
0200-0300	0.0037	0.0070	0.0171	0.0060	0.0067	0.0076	0.0077	0.0105	0.0107	0.0148	0.0126	0.0203
0300-0400	0.0033	0.0049	0.0046	0.0051	0.0054	0.0035	0.0060	0.0046	0.0074	0.0120	0.0107	0.0141
0400-0500	0.0064	0.0042	0.0067	0.0043	0.0068	0.0034	0.0051	0.0049	0.0044	0.0044	0.0086	0.0058
0500-0600	0.0083	0.0049	0.0192	0.0067	0.0089	0.0062	0.0044	0.0020	0.0050	0.0067	0.0060	0.0052

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Kuala Langat

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0469	0.0598	0.0440	0.0661	0.0418	0.0461	0.0407	0.0609	0.0394	0.0137	0.0395	0.0631
0700-0800	0.0819	0.1520	0.0888	0.1209	0.0885	0.1415	0.1031	0.1473	0.0890	0.1410	0.0665	0.1347
0800-0900	0.0793	0.0860	0.0804	0.0632	0.0777	0.0984	0.0711	0.0864	0.0760	0.0814	0.0701	0.0795
0900-1000	0.0555	0.0409	0.0537	0.0315	0.0526	0.0411	0.0535	0.0395	0.0583	0.0439	0.0566	0.0423
1000-1100	0.0582	0.0384	0.0559	0.0315	0.0565	0.0339	0.0517	0.0328	0.0528	0.0389	0.0659	0.0413
1100-1200	0.0608	0.0416	0.0540	0.0312	0.0595	0.0447	0.0599	0.0359	0.0561	0.0318	0.0679	0.0395
1200-1300	0.0591	0.0471	0.0555	0.0408	0.0582	0.0467	0.0569	0.0446	0.0634	0.0591	0.0618	0.0390
1300-1400	0.0571	0.0426	0.0581	0.0565	0.0625	0.0484	0.0635	0.0477	0.0555	0.0436	0.0620	0.0494
1400-1500	0.0653	0.0645	0.0634	0.0650	0.0540	0.0567	0.0565	0.0459	0.0635	0.0759	0.0675	0.0590
1500-1600	0.0674	0.0586	0.0622	0.0612	0.0600	0.0431	0.0663	0.0498	0.0649	0.0520	0.0693	0.0598
1600-1700	0.0621	0.0384	0.0669	0.0486	0.0666	0.0475	0.0664	0.0503	0.0672	0.0397	0.0650	0.0479
1700-1800	0.0798	0.0877	0.0871	0.1049	0.0892	0.1187	0.0832	0.1130	0.0806	0.1024	0.0897	0.1183
1800-1900	0.0854	0.0827	0.0819	0.1005	0.0791	0.0703	0.0797	0.0841	0.0744	0.0924	0.0674	0.0747
1900-2000	0.0651	0.0733	0.0669	0.0868	0.0702	0.0784	0.0628	0.0727	0.0686	0.0835	0.0611	0.0684
2000-2100	0.0424	0.0508	0.0475	0.0562	0.0474	0.0481	0.0476	0.0475	0.0486	0.0533	0.0509	0.0486
2100-2200	0.0337	0.0356	0.0335	0.0352	0.0364	0.0364	0.0371	0.0418	0.0418	0.0475	0.0389	0.0347
2200-2300	0.0273	0.0364	0.0335	0.0309	0.0341	0.0447	0.0327	0.0477	0.0376	0.0402	0.0352	0.0322
2300-2400	0.0265	0.0361	0.0261	0.0320	0.0258	0.0356	0.0252	0.0400	0.0282	0.0352	0.0468	0.0560
0000-0100	0.0142	0.0140	0.0154	0.0213	0.0135	0.0161	0.0170	0.0142	0.0181	0.0181	0.0170	0.0152
0100-0200	0.0083	0.0045	0.0080	0.0052	0.0068	0.0047	0.0087	0.0080	0.0095	0.0060	0.0117	0.0094
0200-0300	0.0053	0.0015	0.0044	0.0020	0.0093	0.0033	0.0052	0.0031	0.0060	0.0034	0.0068	0.0028
0300-0400	0.0037	0.0005	0.0037	0.0009	0.0034	0.0011	0.0049	0.0018	0.0047	0.0008	0.0059	0.0023
0400-0500	0.0066	0.0020	0.0068	0.0032	0.0084	0.0044	0.0059	0.0021	0.0064	0.0050	0.0042	0.0028
0500-0600	0.0148	0.0080	0.0151	0.0076	0.0159	0.0058	0.0157	0.0044	0.0164	0.0100	0.0106	0.0086

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Petaling

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0382	0.0437	0.0382	0.0478	0.0378	0.0414	0.0344	0.0392	0.0320	0.0271	0.0262	0.0375
0700-0800	0.0693	0.1087	0.0709	0.1194	0.0651	0.1171	0.0723	0.1261	0.0661	0.1079	0.0517	0.1051
0800-0900	0.0641	0.0909	0.0648	0.0943	0.0668	0.1035	0.0586	0.0860	0.0623	0.0890	0.0576	0.0827
0900-1000	0.0597	0.0595	0.0549	0.0451	0.0584	0.0504	0.0594	0.0521	0.0619	0.0536	0.0523	0.0720
1000-1100	0.0548	0.0380	0.0572	0.0354	0.0540	0.0381	0.0585	0.0437	0.0504	0.0499	0.0540	0.0420
1100-1200	0.0534	0.0412	0.0554	0.0597	0.0535	0.0460	0.0582	0.0430	0.0559	0.0409	0.0606	0.0445
1200-1300	0.0490	0.0409	0.0513	0.0393	0.0492	0.0416	0.0537	0.0376	0.0582	0.0529	0.0648	0.0485
1300-1400	0.0567	0.0399	0.0614	0.0609	0.0601	0.0510	0.0587	0.0446	0.0524	0.0458	0.0623	0.0577
1400-1500	0.0609	0.0302	0.0622	0.0481	0.0620	0.0456	0.0645	0.0511	0.0609	0.0601	0.0557	0.0413
1500-1600	0.0567	0.0460	0.0572	0.0445	0.0616	0.0397	0.0574	0.0408	0.0567	0.0385	0.0536	0.0346
1600-1700	0.0589	0.0543	0.0608	0.0495	0.0636	0.0585	0.0552	0.0446	0.0518	0.0394	0.0528	0.0335
1700-1800	0.0695	0.0730	0.0676	0.0903	0.0644	0.0830	0.0654	0.0970	0.0630	0.0824	0.0538	0.0540
1800-1900	0.0671	0.0775	0.0657	0.0701	0.0661	0.0612	0.0622	0.0695	0.0669	0.0675	0.0627	0.0667
1900-2000	0.0620	0.0982	0.0571	0.0567	0.0605	0.0599	0.0524	0.0513	0.0589	0.0577	0.0602	0.0655
2000-2100	0.0484	0.0348	0.0409	0.0391	0.0489	0.0468	0.0477	0.0488	0.0549	0.0547	0.0549	0.0533
2100-2200	0.0406	0.0416	0.0353	0.0324	0.0390	0.0392	0.0415	0.0352	0.0443	0.0363	0.0499	0.0460
2200-2300	0.0344	0.0310	0.0280	0.0214	0.0322	0.0278	0.0382	0.0289	0.0326	0.0307	0.0429	0.0286
2300-2400	0.0256	0.0238	0.0240	0.0195	0.0229	0.0205	0.0255	0.0266	0.0267	0.0180	0.0386	0.0257
0000-0100	0.0147	0.0145	0.0132	0.0136	0.0136	0.0181	0.0172	0.0208	0.0233	0.0184	0.0184	0.0246
0100-0200	0.0068	0.0076	0.0077	0.0069	0.0074	0.0069	0.0101	0.0102	0.0098	0.0131	0.0120	0.0172
0200-0300	0.0039	0.0053	0.0129	0.0048	0.0063	0.0060	0.0066	0.0081	0.0088	0.0111	0.0102	0.0146
0300-0400	0.0032	0.0036	0.0041	0.0039	0.0047	0.0027	0.0053	0.0037	0.0062	0.0085	0.0087	0.0102
0400-0500	0.0061	0.0034	0.0063	0.0038	0.0066	0.0034	0.0049	0.0039	0.0046	0.0042	0.0068	0.0047
0500-0600	0.0093	0.0054	0.0170	0.0066	0.0099	0.0059	0.0067	0.0025	0.0073	0.0071	0.0065	0.0056

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Gombak

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0364	0.0337	0.0239	0.0417	0.0336	0.0261	0.0300	0.0333	0.0211	0.0192	0.0170	0.0323
0700-0800	0.0711	0.1163	0.0635	0.0605	0.0695	0.0880	0.0588	0.1025	0.0571	0.0506	0.0357	0.0693
0800-0900	0.0640	0.0789	0.0453	0.0443	0.0531	0.0830	0.0619	0.1016	0.0557	0.0656	0.0458	0.0563
0900-1000	0.0499	0.0438	0.0570	0.0428	0.0600	0.0439	0.0475	0.0460	0.0549	0.0373	0.0511	0.0370
1000-1100	0.0450	0.0471	0.0512	0.0419	0.0551	0.0394	0.0478	0.0351	0.0476	0.0384	0.0350	0.0374
1100-1200	0.0497	0.0466	0.0580	0.0359	0.0471	0.0352	0.0409	0.0357	0.0598	0.0401	0.0430	0.0364
1200-1300	0.0570	0.0500	0.0426	0.0363	0.0486	0.0355	0.0402	0.0325	0.0576	0.0456	0.0364	0.0315
1300-1400	0.0526	0.0601	0.0445	0.0378	0.0393	0.0297	0.0366	0.0283	0.0404	0.0253	0.0417	0.0382
1400-1500	0.0444	0.0616	0.0569	0.0553	0.0545	0.0535	0.0639	0.0529	0.0412	0.0628	0.0562	0.0531
1500-1600	0.0480	0.0451	0.0480	0.0529	0.0592	0.0627	0.0610	0.0515	0.0575	0.0657	0.0613	0.0420
1600-1700	0.0553	0.0481	0.0669	0.0629	0.0620	0.0545	0.0528	0.0422	0.0580	0.0664	0.0600	0.0637
1700-1800	0.0693	0.0811	0.0695	0.0818	0.0758	0.0922	0.0637	0.0668	0.0704	0.0936	0.0705	0.0871
1800-1900	0.0745	0.0684	0.0822	0.1145	0.0684	0.1021	0.0757	0.0860	0.0665	0.1036	0.0773	0.0823
1900-2000	0.0591	0.0442	0.0658	0.0802	0.0603	0.0564	0.0689	0.0678	0.0628	0.0803	0.0679	0.0657
2000-2100	0.0571	0.0366	0.0496	0.0823	0.0555	0.0561	0.0617	0.0614	0.0608	0.0329	0.0647	0.0591
2100-2200	0.0472	0.0338	0.0421	0.0477	0.0425	0.0448	0.0540	0.0414	0.0503	0.0455	0.0561	0.0490
2200-2300	0.0424	0.0334	0.0309	0.0205	0.0366	0.0278	0.0471	0.0267	0.0368	0.0324	0.0560	0.0333
2300-2400	0.0293	0.0227	0.0274	0.0173	0.0254	0.0185	0.0301	0.0259	0.0310	0.0149	0.0446	0.0197
0000-0100	0.0172	0.0168	0.0147	0.0124	0.0154	0.0203	0.0204	0.0264	0.0295	0.0216	0.0233	0.0332
0100-0200	0.0073	0.0098	0.0090	0.0082	0.0086	0.0085	0.0124	0.0125	0.0116	0.0178	0.0150	0.0238
0200-0300	0.0039	0.0074	0.0183	0.0063	0.0071	0.0079	0.0082	0.0111	0.0114	0.0158	0.0139	0.0221
0300-0400	0.0035	0.0052	0.0049	0.0053	0.0058	0.0037	0.0064	0.0049	0.0079	0.0128	0.0117	0.0153
0400-0500	0.0068	0.0044	0.0072	0.0045	0.0072	0.0036	0.0054	0.0052	0.0047	0.0047	0.0094	0.0063
0500-0600	0.0088	0.0052	0.0206	0.0070	0.0094	0.0065	0.0047	0.0022	0.0053	0.0072	0.0066	0.0056

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Hulu Selangor

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0349	0.0498	0.0375	0.0566	0.0417	0.0475	0.0321	0.0479	0.0281	0.0432	0.0212	0.0329
0700-0800	0.0644	0.1180	0.0651	0.1200	0.0653	0.1046	0.0610	0.1207	0.0560	0.1005	0.0427	0.0820
0800-0900	0.0568	0.0798	0.0545	0.0722	0.0603	0.0810	0.0549	0.0723	0.0506	0.0678	0.0430	0.0534
0900-1000	0.0551	0.0506	0.0536	0.0550	0.0560	0.0511	0.0467	0.0507	0.0506	0.0480	0.0468	0.0415
1000-1100	0.0594	0.0406	0.0540	0.0500	0.0559	0.0511	0.0563	0.0510	0.0485	0.0471	0.0568	0.0520
1100-1200	0.0578	0.0508	0.0580	0.0508	0.0573	0.0535	0.0580	0.0482	0.0597	0.0567	0.0542	0.0532
1200-1300	0.0640	0.0648	0.0591	0.0592	0.0620	0.0485	0.0628	0.0644	0.0619	0.0651	0.0541	0.0436
1300-1400	0.0629	0.0619	0.0531	0.0594	0.0563	0.0542	0.0624	0.0566	0.0527	0.0450	0.0554	0.0472
1400-1500	0.0600	0.0500	0.0560	0.0423	0.0584	0.0588	0.0568	0.0359	0.0526	0.0434	0.0545	0.0392
1500-1600	0.0538	0.0473	0.0612	0.0491	0.0557	0.0416	0.0611	0.0390	0.0553	0.0405	0.0622	0.0546
1600-1700	0.0570	0.0431	0.0576	0.0495	0.0606	0.0583	0.0657	0.0531	0.0540	0.0409	0.0638	0.0605
1700-1800	0.0619	0.0695	0.0641	0.0729	0.0639	0.0798	0.0661	0.0674	0.0760	0.0824	0.0684	0.0765
1800-1900	0.0610	0.0559	0.0613	0.0658	0.0634	0.0592	0.0590	0.0592	0.0668	0.0622	0.0650	0.0803
1900-2000	0.0580	0.0524	0.0522	0.0467	0.0501	0.0576	0.0488	0.0486	0.0577	0.0594	0.0584	0.0619
2000-2100	0.0451	0.0359	0.0473	0.0370	0.0451	0.0351	0.0442	0.0439	0.0570	0.0432	0.0483	0.0406
2100-2200	0.0358	0.0305	0.0413	0.0354	0.0392	0.0258	0.0384	0.0327	0.0435	0.0357	0.0410	0.0338
2200-2300	0.0398	0.0316	0.0289	0.0196	0.0345	0.0265	0.0439	0.0252	0.0342	0.0304	0.0510	0.0307
2300-2400	0.0276	0.0215	0.0256	0.0166	0.0239	0.0176	0.0281	0.0244	0.0289	0.0139	0.0406	0.0182
0000-0100	0.0162	0.0159	0.0137	0.0119	0.0145	0.0193	0.0190	0.0249	0.0275	0.0202	0.0213	0.0306
0100-0200	0.0069	0.0093	0.0084	0.0079	0.0081	0.0081	0.0116	0.0118	0.0108	0.0167	0.0136	0.0219
0200-0300	0.0037	0.0070	0.0171	0.0060	0.0067	0.0076	0.0077	0.0105	0.0107	0.0148	0.0126	0.0203
0300-0400	0.0033	0.0049	0.0046	0.0051	0.0054	0.0035	0.0060	0.0046	0.0074	0.0120	0.0107	0.0141
0400-0500	0.0064	0.0042	0.0067	0.0043	0.0068	0.0034	0.0051	0.0049	0.0044	0.0044	0.0086	0.0058
0500-0600	0.0083	0.0049	0.0192	0.0067	0.0089	0.0062	0.0044	0.0020	0.0050	0.0067	0.0060	0.0052

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Kuala Selangor

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0334	0.0402	0.0291	0.0425	0.0328	0.0325	0.0301	0.0374	0.0244	0.0272	0.0205	0.0301
0700-0800	0.0666	0.1232	0.0637	0.1040	0.0658	0.1093	0.0629	0.1202	0.0594	0.0866	0.0416	0.0877
0800-0900	0.0642	0.0772	0.0559	0.0666	0.0616	0.0771	0.0616	0.0867	0.0548	0.0677	0.0464	0.0567
0900-1000	0.0530	0.0430	0.0552	0.0555	0.0565	0.0494	0.0493	0.0479	0.0508	0.0480	0.0526	0.0476
1000-1100	0.0581	0.0479	0.0552	0.0470	0.0568	0.0466	0.0574	0.0523	0.0520	0.0436	0.0554	0.0530
1100-1200	0.0586	0.0505	0.0628	0.0495	0.0570	0.0506	0.0523	0.0413	0.0603	0.0492	0.0565	0.0490
1200-1300	0.0623	0.0562	0.0587	0.0482	0.0554	0.0440	0.0536	0.0454	0.0614	0.0574	0.0551	0.0441
1300-1400	0.0603	0.0532	0.0557	0.0522	0.0533	0.0468	0.0513	0.0432	0.0535	0.0416	0.0560	0.0453
1400-1500	0.0577	0.0505	0.0588	0.0482	0.0613	0.0553	0.0648	0.0468	0.0551	0.0557	0.0592	0.0497
1500-1600	0.0559	0.0471	0.0600	0.0517	0.0596	0.0500	0.0638	0.0451	0.0601	0.0506	0.0630	0.0530
1600-1700	0.0599	0.0495	0.0603	0.0511	0.0627	0.0518	0.0601	0.0471	0.0572	0.0489	0.0613	0.0599
1700-1800	0.0706	0.0832	0.0724	0.0814	0.0786	0.0901	0.0713	0.0798	0.0737	0.0932	0.0700	0.0848
1800-1900	0.0685	0.0723	0.0699	0.0813	0.0672	0.0792	0.0697	0.0756	0.0707	0.0817	0.0694	0.0757
1900-2000	0.0572	0.0568	0.0578	0.0639	0.0567	0.0646	0.0583	0.0587	0.0617	0.0660	0.0607	0.0589
2000-2100	0.0489	0.0425	0.0483	0.0555	0.0510	0.0462	0.0537	0.0539	0.0579	0.0499	0.0588	0.0500
2100-2200	0.0391	0.0310	0.0409	0.0419	0.0403	0.0361	0.0431	0.0356	0.0481	0.0416	0.0461	0.0410
2200-2300	0.0388	0.0308	0.0313	0.0209	0.0346	0.0253	0.0438	0.0251	0.0400	0.0302	0.0476	0.0303
2300-2400	0.0275	0.0193	0.0265	0.0164	0.0236	0.0157	0.0281	0.0220	0.0311	0.0147	0.0380	0.0186
0000-0100	0.0172	0.0132	0.0157	0.0112	0.0159	0.0166	0.0197	0.0207	0.0280	0.0182	0.0221	0.0255
0100-0200	0.0094	0.0078	0.0103	0.0063	0.0090	0.0065	0.0119	0.0094	0.0121	0.0138	0.0135	0.0186
0200-0300	0.0048	0.0054	0.0156	0.0049	0.0074	0.0061	0.0089	0.0083	0.0117	0.0115	0.0117	0.0159
0300-0400	0.0050	0.0045	0.0057	0.0045	0.0061	0.0028	0.0068	0.0037	0.0088	0.0095	0.0096	0.0113
0400-0500	0.0080	0.0039	0.0076	0.0036	0.0084	0.0033	0.0075	0.0046	0.0061	0.0036	0.0084	0.0049
0500-0600	0.0105	0.0049	0.0186	0.0058	0.0112	0.0061	0.0078	0.0023	0.0081	0.0063	0.0069	0.0047

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Sabak Bernam

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0353	0.0333	0.0289	0.0249	0.0270	0.0229	0.0297	0.0273	0.0239	0.0163	0.0209	0.0220
0700-0800	0.0608	0.1289	0.0549	0.1112	0.0576	0.1333	0.0596	0.1428	0.0578	0.0963	0.0358	0.0826
0800-0900	0.0585	0.0624	0.0584	0.0742	0.0649	0.0596	0.0589	0.0819	0.0438	0.0551	0.0396	0.0547
0900-1000	0.0559	0.0434	0.0591	0.0667	0.0476	0.0438	0.0514	0.0447	0.0435	0.0471	0.0612	0.0660
1000-1100	0.0709	0.0610	0.0615	0.0536	0.0629	0.0592	0.0738	0.0898	0.0630	0.0536	0.0781	0.0784
1100-1200	0.0738	0.0610	0.0768	0.0698	0.0716	0.0698	0.0594	0.0498	0.0664	0.0612	0.0702	0.0671
1200-1300	0.0739	0.0624	0.0737	0.0540	0.0554	0.0533	0.0572	0.0451	0.0652	0.0587	0.0674	0.0571
1300-1400	0.0674	0.0491	0.0688	0.0682	0.0635	0.0513	0.0539	0.0498	0.0666	0.0540	0.0643	0.0451
1400-1500	0.0690	0.0519	0.0710	0.0465	0.0766	0.0639	0.0830	0.0578	0.0732	0.0619	0.0697	0.0568
1500-1600	0.0719	0.0568	0.0784	0.0568	0.0711	0.0544	0.0817	0.0435	0.0747	0.0623	0.0762	0.0650
1600-1700	0.0713	0.0638	0.0623	0.0473	0.0742	0.0533	0.0687	0.0494	0.0647	0.0471	0.0740	0.0685
1700-1800	0.0795	0.0939	0.0811	0.0998	0.1033	0.0994	0.0859	0.0949	0.0827	0.1195	0.0861	0.0939
1800-1900	0.0649	0.0865	0.0710	0.0757	0.0708	0.0860	0.0777	0.0807	0.0833	0.0855	0.0794	0.0798
1900-2000	0.0531	0.0592	0.0586	0.0568	0.0545	0.0655	0.0605	0.0546	0.0676	0.0656	0.0610	0.0530
2000-2100	0.0490	0.0540	0.0490	0.0509	0.0566	0.0497	0.0565	0.0550	0.0655	0.0670	0.0645	0.0581
2100-2200	0.0449	0.0326	0.0466	0.0434	0.0423	0.0347	0.0422	0.0328	0.0581	0.0489	0.0517	0.0519
2200-2300	0.0332	0.0266	0.0366	0.0241	0.0328	0.0205	0.0402	0.0233	0.0549	0.0275	0.0325	0.0265
2300-2400	0.0258	0.0116	0.0272	0.0154	0.0212	0.0091	0.0259	0.0134	0.0354	0.0159	0.0263	0.0182
0000-0100	0.0191	0.0042	0.0205	0.0087	0.0190	0.0075	0.0205	0.0067	0.0275	0.0109	0.0226	0.0076
0100-0200	0.0163	0.0028	0.0154	0.0012	0.0110	0.0012	0.0121	0.0016	0.0152	0.0040	0.0119	0.0069
0200-0300	0.0078	0.0004	0.0101	0.0012	0.0090	0.0012	0.0121	0.0012	0.0139	0.0007	0.0076	0.0007
0300-0400	0.0097	0.0028	0.0085	0.0024	0.0076	0.0004	0.0090	0.0008	0.0124	0.0014	0.0055	0.0017
0400-0500	0.0125	0.0028	0.0098	0.0016	0.0127	0.0028	0.0143	0.0032	0.0110	0.0011	0.0070	0.0017
0500-0600	0.0165	0.0046	0.0152	0.0028	0.0176	0.0055	0.0177	0.0028	0.0171	0.0043	0.0091	0.0028

Non-Mc: Non-motorcycles; Mc: Motorcycles

District of Sepang

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0391	0.0718	0.0404	0.0981	0.0404	0.0981	0.0356	0.0478	0.0266	0.0435	0.0279	0.0375
0700-0800	0.0748	0.1020	0.0712	0.1417	0.0712	0.1417	0.0789	0.1077	0.0781	0.1010	0.0457	0.0861
0800-0900	0.0599	0.0559	0.0590	0.0654	0.0590	0.0654	0.0701	0.0899	0.0551	0.0606	0.0648	0.0654
0900-1000	0.0342	0.0237	0.0437	0.0378	0.0437	0.0378	0.0589	0.0421	0.0522	0.0580	0.0619	0.0446
1000-1100	0.0456	0.0147	0.0596	0.0404	0.0596	0.0404	0.0547	0.0465	0.0559	0.0667	0.0389	0.0491
1100-1200	0.0448	0.0212	0.0495	0.0474	0.0495	0.0474	0.0572	0.0631	0.0515	0.0492	0.0500	0.0552
1200-1300	0.0619	0.0445	0.0589	0.0622	0.0589	0.0622	0.0494	0.0485	0.0647	0.0632	0.0603	0.0562
1300-1400	0.0550	0.0196	0.0529	0.0481	0.0529	0.0481	0.0490	0.0459	0.0467	0.0316	0.0566	0.0593
1400-1500	0.0630	0.0477	0.0656	0.0365	0.0656	0.0365	0.0604	0.0434	0.0595	0.0474	0.0536	0.0446
1500-1600	0.0619	0.0571	0.0594	0.0346	0.0594	0.0346	0.0746	0.0625	0.0607	0.0457	0.0483	0.0426
1600-1700	0.0590	0.0445	0.0523	0.0340	0.0523	0.0340	0.0290	0.0408	0.0532	0.0448	0.0638	0.0532
1700-1800	0.0670	0.0669	0.0502	0.0660	0.0502	0.0660	0.0643	0.0720	0.0582	0.0764	0.0527	0.0415
1800-1900	0.0702	0.1755	0.0718	0.0410	0.0718	0.0410	0.0745	0.0638	0.0690	0.0659	0.0701	0.0618
1900-2000	0.0634	0.0747	0.0714	0.0673	0.0714	0.0673	0.0640	0.0351	0.0632	0.0676	0.0710	0.0816
2000-2100	0.0593	0.0624	0.0512	0.0487	0.0512	0.0487	0.0371	0.0427	0.0513	0.0426	0.0574	0.0517
2100-2200	0.0442	0.0245	0.0416	0.0372	0.0416	0.0372	0.0388	0.0402	0.0413	0.0299	0.0555	0.0552
2200-2300	0.0247	0.0330	0.0301	0.0280	0.0301	0.0280	0.0294	0.0426	0.0334	0.0359	0.0309	0.0285
2300-2400	0.0240	0.0328	0.0234	0.0290	0.0234	0.0290	0.0226	0.0357	0.0250	0.0315	0.0411	0.0496
0000-0100	0.0129	0.0127	0.0139	0.0193	0.0139	0.0193	0.0152	0.0127	0.0161	0.0162	0.0149	0.0135
0100-0200	0.0075	0.0041	0.0072	0.0048	0.0072	0.0048	0.0078	0.0071	0.0085	0.0054	0.0103	0.0083
0200-0300	0.0048	0.0014	0.0040	0.0018	0.0040	0.0018	0.0047	0.0028	0.0054	0.0031	0.0060	0.0025
0300-0400	0.0033	0.0005	0.0034	0.0008	0.0034	0.0008	0.0044	0.0016	0.0042	0.0007	0.0052	0.0020
0400-0500	0.0060	0.0018	0.0061	0.0029	0.0061	0.0029	0.0052	0.0018	0.0057	0.0045	0.0037	0.0025
0500-0600	0.0134	0.0072	0.0136	0.0069	0.0136	0.0069	0.0141	0.0039	0.0146	0.0089	0.0093	0.0076

Non-Mc: Non-motorcycles; Mc: Motorcycles

Federal Territory of Kuala Lumpur

Time	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc	Non-Mc	Mc
0600-0700	0.0390	0.0242	0.0390	0.0308	0.0391	0.0299	0.0340	0.0290	0.0318	0.0257	0.0235	0.0328
0700-0800	0.0647	0.0913	0.0661	0.1073	0.0549	0.1107	0.0628	0.1313	0.0569	0.1075	0.0481	0.1047
0800-0900	0.0567	0.1052	0.0605	0.1188	0.0648	0.1232	0.0489	0.0894	0.0567	0.1040	0.0540	0.1016
0900-1000	0.0712	0.0836	0.0592	0.0488	0.0630	0.0537	0.0658	0.0604	0.0703	0.0567	0.0500	0.1000
1000-1100	0.0559	0.0406	0.0594	0.0322	0.0525	0.0354	0.0646	0.0469	0.0482	0.0531	0.0558	0.0383
1100-1200	0.0519	0.0451	0.0585	0.0784	0.0546	0.0473	0.0625	0.0431	0.0590	0.0409	0.0646	0.0447
1200-1300	0.0412	0.0337	0.0472	0.0298	0.0427	0.0363	0.0532	0.0324	0.0562	0.0491	0.0719	0.0509
1300-1400	0.0565	0.0429	0.0694	0.0728	0.0661	0.0562	0.0623	0.0472	0.0522	0.0510	0.0660	0.0644
1400-1500	0.0588	0.0123	0.0653	0.0467	0.0665	0.0458	0.0721	0.0596	0.0652	0.0631	0.0548	0.0330
1500-1600	0.0547	0.0437	0.0586	0.0416	0.0666	0.0379	0.0525	0.0310	0.0554	0.0334	0.0497	0.0199
1600-1700	0.0593	0.0642	0.0647	0.0562	0.0699	0.0732	0.0573	0.0402	0.0475	0.0360	0.0474	0.0169
1700-1800	0.0674	0.0660	0.0635	0.0987	0.0598	0.0769	0.0615	0.1043	0.0588	0.0793	0.0421	0.0274
1800-1900	0.0608	0.0521	0.0601	0.0706	0.0608	0.0559	0.0530	0.0629	0.0663	0.0570	0.0608	0.0636
1900-2000	0.0651	0.1302	0.0513	0.0411	0.0539	0.0467	0.0453	0.0445	0.0558	0.0461	0.0600	0.0672
2000-2100	0.0505	0.0207	0.0328	0.0264	0.0483	0.0461	0.0484	0.0483	0.0589	0.0577	0.0547	0.0554
2100-2200	0.0454	0.0540	0.0339	0.0275	0.0383	0.0404	0.0442	0.0315	0.0468	0.0332	0.0555	0.0511
2200-2300	0.0358	0.0288	0.0257	0.0182	0.0311	0.0242	0.0390	0.0227	0.0303	0.0271	0.0438	0.0267
2300-2400	0.0248	0.0196	0.0228	0.0154	0.0216	0.0161	0.0250	0.0220	0.0256	0.0125	0.0349	0.0158
0000-0100	0.0145	0.0145	0.0122	0.0110	0.0131	0.0177	0.0169	0.0224	0.0243	0.0181	0.0183	0.0267
0100-0200	0.0062	0.0084	0.0074	0.0073	0.0073	0.0074	0.0103	0.0106	0.0096	0.0149	0.0117	0.0191
0200-0300	0.0033	0.0063	0.0152	0.0056	0.0060	0.0069	0.0068	0.0095	0.0094	0.0132	0.0108	0.0177
0300-0400	0.0030	0.0045	0.0041	0.0047	0.0049	0.0032	0.0053	0.0042	0.0065	0.0107	0.0092	0.0123
0400-0500	0.0058	0.0038	0.0059	0.0040	0.0061	0.0032	0.0045	0.0044	0.0039	0.0039	0.0074	0.0051
0500-0600	0.0074	0.0045	0.0171	0.0062	0.0080	0.0056	0.0039	0.0018	0.0044	0.0060	0.0051	0.0045

Non-Mc: Non-motorcycles; Mc: Motorcycles

APPENDIX B

Daily and Monthly Factors

Daily Factors (DF)	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	0.9535	0.9912	1.0026	1.0145	1.0352	1.0068
Monthly Factors (MF)	**January**	**February**	**March**	**April**	**May**	**June**
	1.0551	0.9930	1.0519	1.0878	1.0225	0.9602
	July	**August**	**September**	**October**	**November**	**December**
	1.0265	0.9710	0.8745	0.9348	1.0020	1.0354

APPENDIX C

Calculation of AADT for Motorcycles on Major and Minor Roads of Three-legged Non-Signalised Junctions

Node	Motorcycles on Major Road						Motorcycles on Minor Road					
Number	V-1h	HF	V-24h	DF	MF	AADT	V-1h	HF	V-24h	DF	MF	AADT
601290	635	0.0451	14095	1.0352	1.0225	14920	134	0.0451	2980	1.0352	1.0225	3154
601400	387	0.0361	10715	1.0145	1.0225	11114	70	0.0361	1944	1.0145	1.0225	2016
601470	509	0.0350	14535	1.0026	1.0225	14900	108	0.0350	3088	1.0026	1.0225	3165
601700	1030	0.0857	12019	0.9912	1.0225	12180	204	0.0857	2381	0.9912	1.0225	2413
601890	512	0.0863	5936	1.0352	1.0225	6283	131	0.0863	1520	1.0352	1.0225	1609
607460	916	0.0432	21203	0.9912	0.9348	19646	180	0.0432	4176	0.9912	0.9348	3869
607860	550	0.0413	13320	1.0026	0.9348	12484	107	0.0413	2582	1.0026	0.9348	2420
608120	550	0.0602	9139	1.0352	1.0020	9479	117	0.0602	1945	1.0352	1.0020	2018
608140	419	0.0419	9989	1.0352	1.0020	10362	89	0.0419	2126	1.0352	1.0020	2205
608280	401	0.0410	9779	1.0352	1.0020	10143	87	0.0410	2129	1.0352	1.0020	2208
611820	404	0.0408	9909	0.9912	1.0225	10042	85	0.0408	2082	0.9912	1.0225	2110
612150	551	0.0446	12359	1.0145	1.0225	12820	95	0.0446	2128	1.0145	1.0225	2207
612260	612	0.0591	10354	1.0352	0.9602	10292	119	0.0591	2013	1.0352	0.9602	2001
612310	1485	0.1024	14496	1.0352	0.9602	14410	293	0.1024	2857	1.0352	0.9602	2840
612470	630	0.0426	14782	0.9535	1.0225	14412	124	0.0426	2915	0.9535	1.0225	2842
613030	710	0.0565	12557	0.9912	1.0225	12726	135	0.0565	2395	0.9912	1.0225	2427
613070	671	0.0408	16452	0.9912	1.0225	16673	129	0.0408	3169	0.9912	1.0225	3212
613460	841	0.0467	18007	1.0026	1.0225	18460	164	0.0467	3512	1.0026	1.0225	3600
613540	1221	0.0660	18504	0.9912	0.9602	17610	237	0.0660	3589	0.9912	0.9602	3416
613570	756	0.0565	13370	0.9912	0.9602	12724	156	0.0565	2754	0.9912	0.9602	2621
613590	477	0.0408	11688	0.9912	0.9602	11124	87	0.0408	2122	0.9912	0.9602	2020
614540	583	0.0419	13907	0.9535	0.9348	12396	123	0.0419	2943	0.9535	0.9348	2623
614810	533	0.0392	13591	0.9535	0.9348	12114	97	0.0392	2482	0.9535	0.9348	2212
614910	426	0.0389	10941	1.0026	0.9348	10255	92	0.0389	2362	1.0026	0.9348	2214
615260	1148	0.0888	12927	1.0026	0.9348	12116	210	0.0888	2364	1.0026	0.9348	2216
640450	640	0.0432	14805	0.9912	0.9348	13718	113	0.0432	2620	0.9912	0.9348	2428
640980	489	0.0392	12482	0.9535	0.9348	11126	88	0.0392	2233	0.9535	0.9348	1991
642480	589	0.0510	11565	1.0352	1.0225	12241	119	0.0510	2337	1.0352	1.0225	2474
642510	490	0.0509	9629	1.0068	1.0225	9912	99	0.0509	1945	1.0068	1.0225	2003
643660	1250	0.0660	18938	0.9535	1.0225	18464	244	0.0660	3703	0.9535	1.0225	3610
646010	205	0.0471	4361	0.9535	1.0225	4252	67	0.0471	1423	0.9535	1.0225	1388
646130	580	0.0446	12990	1.0145	0.9602	12653	74	0.0446	1666	1.0145	0.9602	1623
646150	634	0.0477	13290	1.0145	0.9602	12946	94	0.0477	1967	1.0145	0.9602	1916
649790	327	0.0324	10096	1.0145	1.0225	10472	69	0.0324	2138	1.0145	1.0225	2218
655750	802	0.0660	12160	1.0145	1.0225	12613	167	0.0660	2535	1.0145	1.0225	2630
658770	243	0.0436	5577	1.0352	0.9602	5544	71	0.0436	1622	1.0352	0.9602	1612

Notes: V-1h: 1-hour Traffic Volumes; HF: Hourly Factors; V-24h = V-1h / HF
V-24h: Estimated 24-hour Traffic Volumes; AADT = V-24h x DF x MF (Motorcycles/day)
AADT: Annual Average Daily Traffic; DF: Daily Factors; MF: Monthly Factors

APPENDIX D

Multivariate Analysis of the Terms

Explanatory Variable	Estimate	Standard Error	Degrees of Freedom	Scaled Deviance	t-value	Sig.at 5% Level	Mean Deviance
Constant	-7.412	0.344	52	3112	-21.58	Yes	59.8
AADTmajor	0.5369	0.0405	51	137.6	13.25	Yes	2.7
AADTminor	0.2869	0.0336	50	65.1	8.54	Yes	1.3
SHDW	-0.0864	0.0215	49	49	-4.01	Yes	1

ELECTRONIC TOLL COLLECTION SYSTEM: A ROAD MANAGEMENT TOOL

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ABSTRACT

The highway authority of the Japanese Government is dealing with the implementation of Electronic Toll Collection (ETC) as one of the top priority issues of the highway administration. Since the introduction of commercial operation of ETC in 2001, a great deal of effort such as several promotion campaigns with public subsidies or instalment of ETC gantry systems has been put into promoting the system. As a result, the numbers of ETC units installed in cars, and the average ETC coverage at toll gates, reached about 7 million, and accounted for more than 40%, respectively at the end of May 2005. The introduction of ETC has resulted in many advantages for road users as well as toll road operators, including the mitigation of traffic congestion and user inconvenience, introduction of toll discounts for ETC users and so on. As a result of the nation-wide introduction and diffusion of ETC systems, several other features such as integration to a distance travelled toll system, the addition of cheap and simple interchanges or ramps, and the execution of full scale road pricing will be possible in the near future.

This paper describes the introduction of the ETC system into tollways in Japan Since the introduction of the ETC toll system in 2001, the effects and impacts on the community have been much larger than initially envisaged. ETC is one of the highest priority issues in the highway administration, and the use of the system is increasing very rapidly as its effectiveness is recognised by road users.

1. INTRODUCTION

Electronic Toll Collection (ETC) allows the non-stop, automatic collection of tolls. Since the introduction of the ETC toll system into Japan in 2001, the effects and impacts on the community have been much larger than initially envisaged. ETC is one of the highest priority issues in the highway administration, and the use of the system is increasing very rapidly as its effectiveness is recognised by road users.

2. INNOVATION OF TECHNOLOGY AND ITS DIFFUSION

2.1 Targets of technology innovation

Since the development of ETC in 1993, five targets of technology innovation were identified. It was recognised that the system should:

- be applicable to all types of toll roads and vehicles
- allow easy tracing of usage and be adaptable to both pre/post-payment methods
- be highly accuracy, secure and private
- be reasonably priced if the on-board equipment was to be readily adopted
- involve a two-tier system for toll collection: coexistence of conventional and ETC system for a certain period.

2.2 ETC system architecture

The main outcomes of research and development work conducted since 1993 by teams of academic, public and private experts were as follows.

- A 5.8 GHz-band active Dedicated Short Range Communication (DSRC) system was adopted in order to ensure precise interactive communication between vehicles and gantry systems with high reliability, expandability, and efficient use of limited frequency resources.

- A 'two-piece method was adopted: users acquire an ETC card with an IC chip which contains their personal information. This is issued by credit card companies. They also purchase on-board equipment with particular vehicle information. The on-board equipment is installed by car dealers, car parts shops or gas stations. The cost is about 15,000 to 25,000 yen[1] .

- The gantry system consists of an antenna, vehicle detectors, camera, message signs and barrier. The cost required for shifting to an ETC gate is around 80 million yen pergantry.

[1] 1,000 JPY = US$8.60

2.3 Process of Development and Adoption

The research and development work that commenced in 1993 was mainly conducted by public and academic experts. In 1994, two technical committees were established, one is the System Architecture Committee chaired by Prof. Hideo Nakamura of civil engineering, and the other is the system evaluation committee by Prof. Mitsutosi Hatori of telecommunication. In 1995, experts from the private sector joined the project teams.

The commercial operation of ETC partly commenced in 2001, involving only 63 toll plazas. Now of the 1261 toll plazas, 96% are operated by ETC. By may 2005 the number of ETC-equipped vehicles reached about 7 million, and 42% of vehicles passing through toll gates used the ETC system.

Figure 1 shows the growth in the number of ETC cars. The line on the graph indicates the monthly growth of registered ETC vehicles. In June 2003 and November 2004, publicly-subsidised promotion campaigns were carried out which contributed a great deal to the rapid adoption of ETC.

2.4 Toll Road Operators

The major toll motorway networks in Japan are managed by four national public corporations and other local ones. Inter-urban motorways form a major part of the toll road system. They are mainly constructed and operated by the Japan Highway Public Corporation (JH), the largest toll road operator in the world. It has two types of motorways, the main one being a 'travelled distance' toll system, where users take a ticket at the entrance and pay the toll at the exit. It also operates some toll roads which operate under a 'fixed section, unit toll' system.

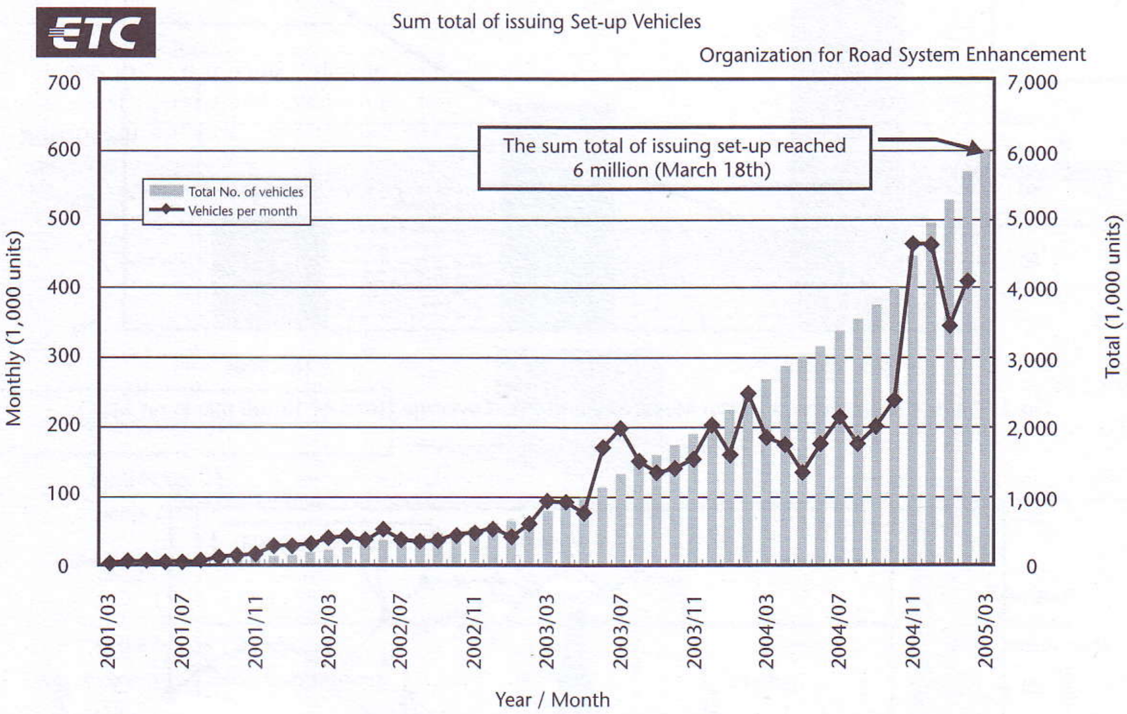

Figure 1: Growth of Cars Installed with ETC

Five major cities in Japan have urban motorway networks. They generally apply the zone unit toll system in which user pays the toll at the entrance to the motorway. In October 2005, four national public corporations were privatised and divided into five private companies and one infrastructure holding agency.

3 ETC BEST PRACTICE

3.1 Reduction of congestion and user inconvenience

The existence of different toll systems causes inconveniences to drivers who drive long distances because they may have to stop at many times at different toll gates in some regions. For example, people travelling from Kyoto to the Kansai International Airport, about 100 km from the city centre, used to have to stop at six different toll gates but, since the introduction of ETC, this is no longer required.

One-third of the traffic congestion in Japan occurs at toll gates on motorways. The use of ETC in vehicles has led to a big reduction in congestion at toll gates because of the large difference in handling capacity compared to manual systems. For example, Figure 2 compares the linear growth of ETC coverage (right hand scale) with the change in congestion volume (left hand scale) on the Tokyo Expressway. Congestion volume (km-h / day) is defined as the daily total congestion length (km), which changes hour by hour, multiplied by each corresponding congestion time. The handling capacity of ETC gates is about 800 vehicles/hour/lane, 3.5 times faster than the manual systems (230 vehicles/hour/lane).

Figure 3 compares the congestion lengths at Tokyo Toll Plaza on 2 January in 2004 and 2005. This toll plaza is the biggest in Japan, having 18 gates for one direction. The longest congestion length in 2004 was 25 km at noon, due to the concentration of road users returning from their winter vacation. The congestion length in 2005 was much lower, about 14 km, even though the traffic volumes were similar to the previous year. During this one year period, the ETC coverage grew from 15% to 30%. Clearly, the adoption of ETC contributed a large decrease in congestion.

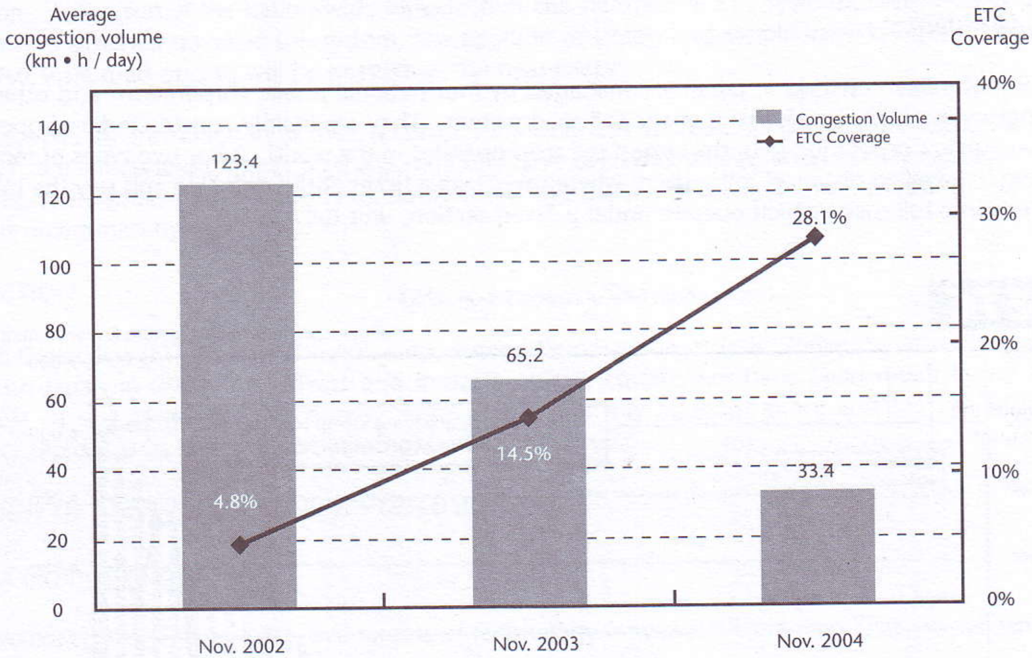

Fig-2 Traffic Congestion on Urban Motorway and ETC Coverage (total of 18 toll plazas on MEX)

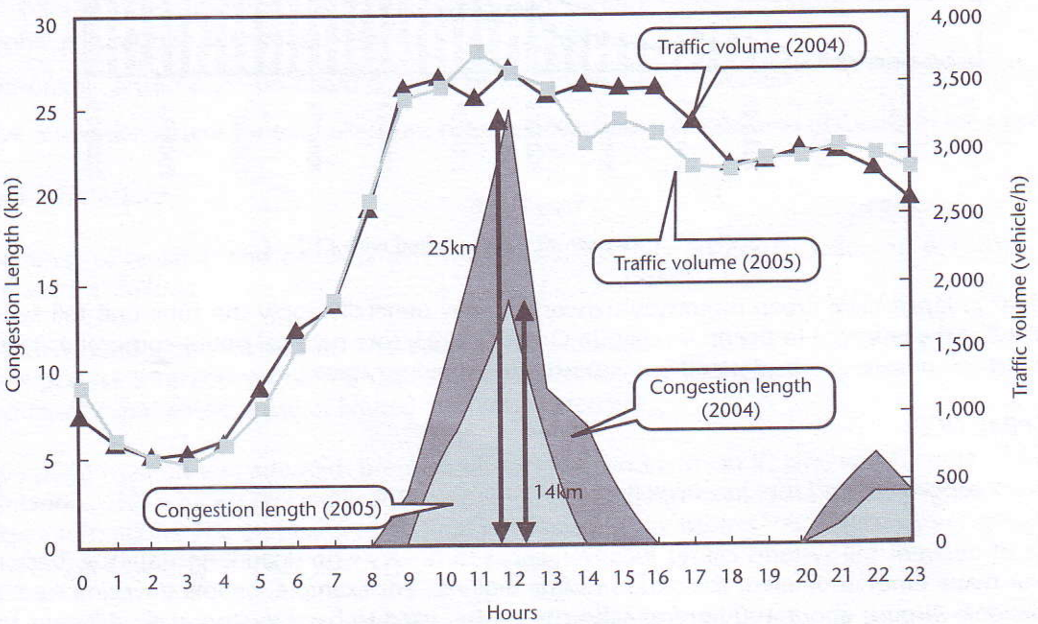

Figure 3: Congestion Length at Tokyo Toll Barrier after Winter Vacation

3.2 Introduction of toll reduction systems for inter-urban motorways

In the course of the Parliamentary debate regarding the privatisation of the four national public corporations, the Government promised to reduce the toll level by 10%. However, the road administrators and motorway operators responded by not reducing the toll to all road users by the same rate. They also attempted to discontinue all the existing discounts which were sometimes the source of fraudulent behaviour and aimed to establish a new discount system exclusively for the use of ETC users; this involved a 10 % reduction in cost if ETC was adopted by users at the same time.

The previous and new discount systems are compared in Figure 4. The new discounts amounted to 460 billion yen, equal to the previous reductions (280 billion yen) plus the promised 10% of total income (180 billion yen).

In terms of the new discount system, three categories of 'time of the day' were introduced since January 2005. They offer a 50% discount in toll for car commuters in rural areas, a 50% discount for early morning and night users in urban areas and a 30% discount for all late night users. The aim is to encourage the use of motorways during those times of the day when there is sufficient capacity and also to enhance the environmental conditions on minor roads by attracting vehicles to the motorways.

Since April 2005, two types of mileage services have been introduced for high-usage vehicles.

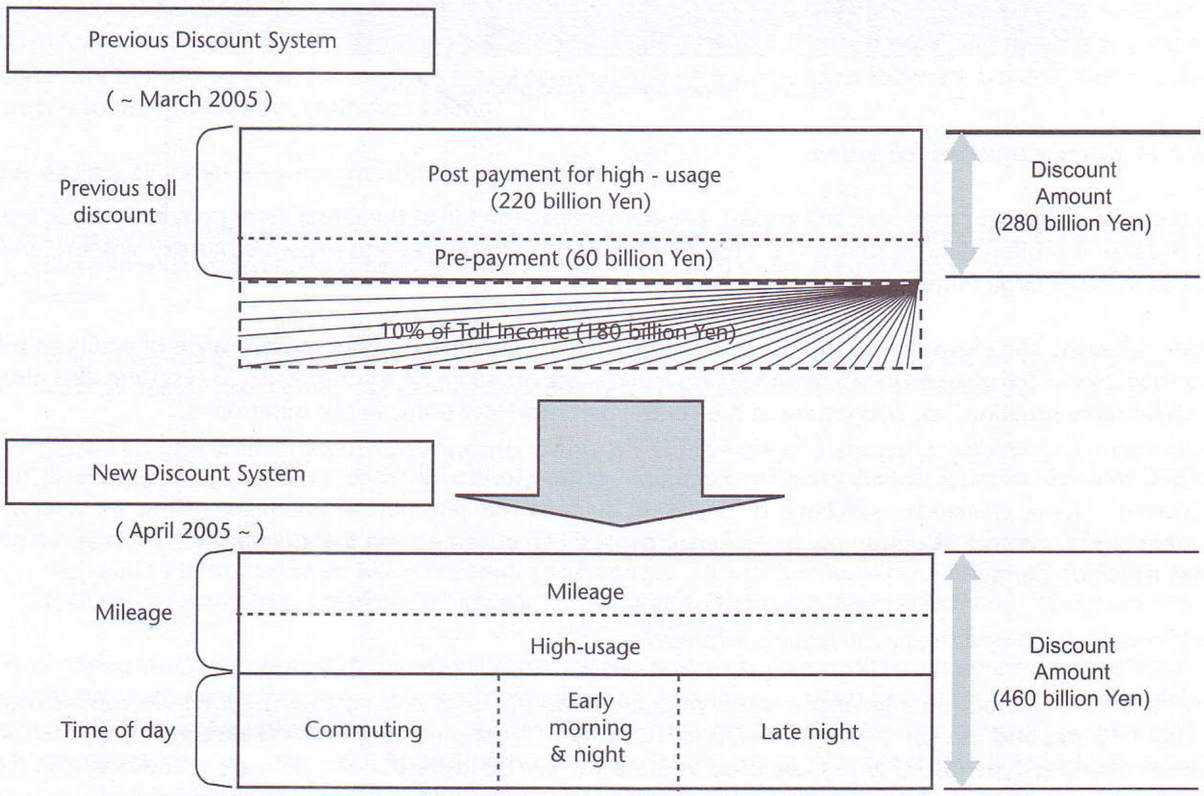

Figure 4: Toll discount system for inter-urban motorways

So-called environmental road pricing, targeting heavy ETC vehicles, was introduced, after trialling, for urban motorways in the Tokyo and Kobe areas in 2001. Figure 5 shows the example of the Hanshin Expressway. The toll charge on the coastal motorway in industrial areas is 20% less than that for the parallel roads in residential areas.

Since the introduction of this pricing system, some heavy vehicles have shifted to the newly-constructed coastal section. The effects of the introduction of the new pricing system, in terms of improvement in environmental conditions, air and noise, in residential areas, has not yet been determined.

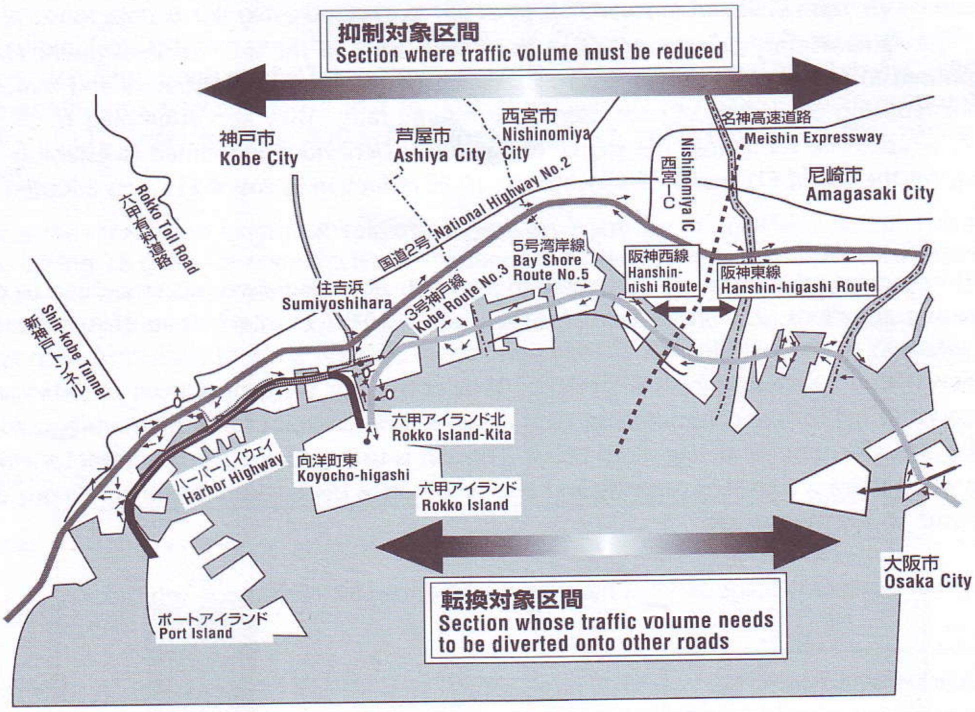

Figure 5: Environmental road pricing in Kobe

3.3 Shift to distance travelled toll system

Urban motorways apply a 'zone unit' toll system, where users pay the toll at the entrance but pay nothing at the exit. This is because it is often difficult to install a large number of on / off ramps, and expensive gantry systems, and also difficult to manage large numbers of toll gates in urban areas.

However, following the expansion of the urban motorways, there has been a growing imbalance of equity of burden among road users. Toll charges for 3 km and 40 km lengths are the same on this network. This system also gives rise to an undesirable situation, viz. congestion in the central parts and low traffic in the outer parts.

Whilst ETC makes it possible to shift from the 'zone unit' system to the 'distance travelled' system, this shift has not yet occurred. Some challenges still have to be faced, such as the selection of adequate tolling technology, the installment of ETC gantries at off-ramps, the enhancement of ETC coverage and the identification of issues associated with the transition period.

3.4 Addition of cheap and simple interchanges/ramps

Conventional interchanges on inter-urban motorways are generally large and costly. The intervals can be relatively long, about 10 km, and this can be inconvenient for users. If ETC gantries were installed on each ramp, then simple and cheap diamond-type interchanges could be in place for the exclusive use of ETC users. However, this type of interchange has yet to be developed but is a challenge which must be addressed in the near future.

Currently, surveys of ETC cars are being conducted on 28 interchanges connecting service and parking areas to access roads.

4. CONCLUSION

This paper has described the introduction of the ETC system into tollways in Japan Since the introduction of the ETC toll system in 2001, the effects and impacts on the community have been much larger than initially envisaged. ETC is one of the highest priority issues in the highway administration, and the use of the system is increasing very rapidly as its effectiveness is recognised by road users. As a result of the introduction of the ETC system, toll charges can be varied that be adapted to a number of variables including vehicle axle load, road quality, distance travelled, time of day travelled, level of congestion and other relevant criteria.

COMMUNITY ROAD SAFETY – RECENT DEVELOPMENTS IN AUSTRALIA WITH POSSIBLE RELEVANCE FOR DEVELOPING COUNTRIES

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ABSTRACT

Community Road Safety (CRS) has by now become accepted as an important part of the delivery of road safety in most Australian States and Territories. This has come about as central authorities have come to realise that some aspects of road safety are best delivered at the local level, and communities have come to realise there is much they can do with their own resources to improve their own safety. As part of taking stock of progress in community road safety, Austroads commissioned a review of community road safety in Australia and New Zealand. The aims of this paper are to present the basic principles relating to objectives and structures developed in the Austroads project, to report on the progress made in the Tasmanian CRSP program based on these principles, and to discuss the possible relevance of these principles and findings for developing countries.

1. INTRODUCTION

Community Road Safety (CRS) has become accepted as an important part of the delivery of road safety in most Australian States and Territories. This has come about as central authorities have come to realise that some aspects of road safety are best delivered at the local level, and communities have come to realise there is much they can do with their own resources to improve their own safety.

The advantages of community programs include the following.

- They can deal effectively with issues missed by mainstream programs, since remedial actions planned at the State level have traditionally been driven by accident histories or, to a lesser extent, by safety audits on major roads.
- They have the potential to reach individuals and groups which are not reached by conventional media, such as marginalised groups or groups or people with poor understanding of the official language.
- They can give a local focus to programs delivered State-wide or nationally, boosting the credibility of the messages and emphasising the relevance of the messages to each particular community.
- Programs at the local level are able to achieve a better understanding of how the local community use the road system and their likely reaction to changes. This understanding has the potential to provide solutions to road safety problems which are well tailored to the needs and expectations of the community.

As part of taking stock of progress in community road safety, Austroads commissioned a review of community road safety in Australia and New Zealand. The project involved an extensive program of visits to community road safety programs throughout Australia and New Zealand, visits to the officers of State and national government who administer these programs, and workshop meetings with experienced managers of community road safety programs. A report was produced (Cairney 2002) which provided an overview of CRS in Australia and New Zealand at that time, identified the key objectives of CRS programs, the institutional arrangements required for sustainable CRS programs, and the issues which need to be addressed to ensure a healthy future for community road safety.

Tasmania is the latest Australian jurisdiction to establish a community road safety program. The Community Road Safety Partnership (CRSP) Program was initiated by the Department of Infrastructure, Energy and Resources (DIER) with the aim of establishing road safety partnerships with Tasmanian local governments and communities. The process of setting up the program was influenced to a considerable extent by the Austroads report. Two years after the launch of the program, when the individual partnerships with local authorities had been going for between 14 and 22 months, ARRB Consulting was asked to evaluate the program (Cairney 2005).

The aims of this paper are to present the basic principles relating to objectives and structures developed in the Austroads project, to report on the progress made in the Tasmanian CRSP program based on these principles, and to discuss the possible relevance of these principles and findings for developing countries.

2. CONCEPTUAL FOUNDATIONS

The formal conceptual foundations of CRS may be traced to the World Health Organisation's Ottawa Charter for Health Promotion (WHO 1986), which was an outcome of the First International Conference on Health Promotion held in Ottawa, Canada in 1986. The Charter recognised that improvements in health required strong health advocacy, empowerment of individuals to take control of their own health, and the coordination of all involved.

The Ottawa Charter was one of the driving forces which led to the First International Conference on Injury Prevention, Stockholm, 1991, which in turn led to the Safe Communities program and explicit links to road safety.

Some 15 years on, the 'official' safe communities movement would appear to have had relatively little impact, if judged on the basis of communities and support centres which had signed up as designated members of the WHO Safe Communities Program. Only 83 communities are enrolled in the program world-wide according to the current (but apparently dated) web page from Sweden's Karolinska Institute, the co-ordinating body for the program <http://www.phs.ki.se/csp/safecom/default.htm>.

However, it would seem that the Safe Communities program has had an influence well beyond what membership of the official program would indicate. This is very much the case in the United States, which has only two cities entered in the WHO Safe Communities Program, but has a very active Safe Communities Program sponsored and supported by the National Highway Traffic Safety Administration (NHTSA). A recent check of the website showed that over 800 communities across the nation were participating, with participating communities in almost every state.

In Australia, the concept of Safe Communities came on the scene at about the time when road safety planning moved into a more formal phase, with the release of Road Safety Plans in New South Wales and Victoria, followed by the development of a national plan.

To a large degree these plans, and the plans from other Australian jurisdictions which followed them, were a formalisation of trends and procedures which had been evolving over a number of years, including:

- The recognition of a rational scientific approach to problem identification and countermeasure evaluation.
- A recognition of the value of cooperation and coordination amongst all stakeholders, but especially between road and traffic authorities and police.
- Some highly successful initiatives which made a dramatic difference in road safety, encouraging belief that the problem was manageable, and encouraging road and traffic authorities and police to assume responsibility for the directions of road safety.

These road safety plans specifically recognise the role of local government as a key stakeholder in road safety and acknowledge the importance of establishing ownership of road safety problems by the community at large. It was a logical step to apply the processes which proved to be successful at the State and national level to a local level, adopting a systematic approach to problem identification and countermeasure evaluation, encouraging community ownership of problems and their solution, and establishing a working partnership among the major stakeholders.

Five of Australia's eight jurisdictions now have explicit community road safety programs, although these programs vary considerably in their organisation and the level of resource commitment. New Zealand also has a comprehensive program which engages almost all local authorities. Those jurisdictions which do not have a community program as such nevertheless deliver many of their activities at a community level and work closely with communities on a range of issues.

Community Road Safety (CRS) is therefore a rather imprecise term. Although the administrative detail is different, the essential characteristics are clear:

- Action initiated and managed at the local (rather than the national or state level).
- Action to tackle problems in the local area – the problems themselves may be essentially local problems arising from local conditions, or more general problems experienced widely throughout other communities.
- Involvement of the local community and the involvement of local groups as service deliverers or in enhancing awareness of road safety issues.

3. KEY OBJECTIVES OF COMMUNITY ROAD SAFETY

The objective of community road safety is always to reduce road deaths and injuries. Ideally, community road safety should be carried out on a sustainable basis, rather than an intermittent series of activities. Making community road safety sustainable involves a number of indirect approaches as well as actions directly targeted at specific issues. It is therefore useful to think in terms of a number of subsidiary objectives which relate to creating awareness of the problems of road safety and potential solutions, motivating the community and creating a climate in which community-based actions can thrive. These objectives may be conceptualised as follows:

Creating an informed community: Raising the salience of road safety issues; creating informed views on road safety; creating informed activism.

Mobilising local resources to road safety ends: Mobilising additional resources; creating a sense of ownership; encouraging community involvement; enhancing the sense of community.

Promoting effective action: Targeting resources to risk in the community; complementing and enhancing State-wide objectives; effective contribution to road safety outcomes; encouraging good practice; encouraging innovation; influencing key stakeholders.

Integrating activities: Ensuring mutually supportive activities; creating a road safety culture. These objectives all contribute to capacity building, i.e. the creation of the collective confidence, social networks and store of practical experience which enable communities to tackle new issues. As capacity grows the range and complexity of the issues which can be tackled increases.

4. CONDITIONS FOR A SUCCESSFUL COMMUNITY ROAD SAFETY PROGRAM

What institutional structures and resources are required for an effective community road safety program? Experience has shown that there are certain minimum requirements at the local level and at the level of State or National government. While local knowledge, effective working partnerships and volunteers have to come from the local level, central government has an important role in providing general guidance, expert advice and funding support.

There is general agreement that community road safety activities will operate best if there is a community road safety strategy in place to ensure a sustainable systematic approach to road safety issues.

4.1 Requirements at the local level

A stable representative local body: There needs to be a body at the local level to be responsible for the carriage of the strategy (or the direction of activities where there is no strategy), to coordinate stakeholders and to interact with central government. In Australia and New Zealand, this body is usually the local Council, or some group established under the auspices of the Council.

Effective local personnel: Under many models of community road safety, this primarily means a Road Safety Officer/Coordinator who is capable of managing road safety activities and all they entail. At the very least it means someone from the community who is capable of managing carriage of the plan or organisation of ad hoc activities in addition to their normal duties: this is almost always someone from Council or one of the major stakeholder organisations who takes it as an additional duty.

Effective partnerships: It is essential that there be good working relationships between stakeholder organisations at the local level, and that they agree about their respective roles and responsibilities in striving for shared goals.

Commitment of local resources: Funding, contributions in kind, and volunteer input are all required. Local funding commitments need not be large. However, central government often offers assistance on a dollar-for-dollar basis, and there may be community demand for projects which do not receive support from current central government programs. Contributions in kind, such as the use of vehicles, venues and advertising can result in projects being run at very low cost. Volunteer activity is the essence of many community road safety activities, and is generally mobilised through existing community organisations such as service clubs.

4.2 Requirements at the central level

Management support: It is essential that central government provide a framework for the management of community road safety. This entails a number of elements, such as creating a program so that decision processes are transparent

and all communities can be treated on an equal manner, creating a generally supportive climate for community road safety through press releases, planning of Statewide or nationwide activities, and briefing of its own regional staff, and providing effective models for road safety strategies and for individual road safety activities.

Commitment-to-community road safety: Communities need to be assured that central government has a long-term commitment to community road safety, and that they will not be left to their own devices having gone to the effort of establishing a strategy and a program. Public pronouncements committing the government to support over a number of years are important in building up confidence in the process.

Expert advice: It is unrealistic to expect that expert advice is available for all road safety matters within Council. State or National road or road safety authorities generally have this advice available, and so can advise on which problems have potentially feasible solutions, how to go about implementing these solutions, and perhaps even to provide expert services such as running seminars.

Screening process for activities: Central government should provide quality control to ensure that projects which are carried out with its financial support are directed towards well planned activities that support worthwhile community road safety objectives and that have a good chance of succeeding. It is essential that this screening process be based on sound criteria which are made known to the participating communities, and that communities receive adequate feedback from the central authority regarding unsuccessful funding applications. It is also desirable that the process should not be too rigidly defined and that it should leave room for differences among communities in the way in which projects are to be carried out.

Evaluation: The central government should undertake two levels of process evaluation. It should continually monitor its own processes and interactions with communities, and should also conduct meta-evaluations of projects being carried out by individual municipalities, i.e. it should continually monitor what the experience of different types of project has been across different municipalities. It is also appropriate for the central authority to attempt outcome, although the difficulties associated with this should not be underestimated. A full discussion of the issues associated with evaluation are a major feature of the full report on this project (Cairney, in press).

5. THE TASMANIAN COMMUNITY ROAD SAFETY PARTNERSHIP PROGRAM

The design and objectives of the Tasmanian CRSP program were influenced by the Austroads review of community road safety in Australia and New Zealand referred to in the introduction (Cairney 2002). The objectives of community road safety and requirements for institutional structures set out in that report were used as the evaluation framework.

The evaluation was based on a number of separate data gathering tasks, including visits to three Councils to speak to key stakeholders, a questionnaire to each CRSP committee, questions targeted at CRSP issues which were embedded in a State-wide survey which looked at a wide range of road safety issues, an analysis of print media coverage of CRSP projects and events, and four evaluation reports completed as part of individual CRSP projects.

5.1 Findings

From the visits, it was clear that the institutional arrangements were working well, and that the Committees were growing in confidence and understanding. The essential community road safety goals of creating a an informed community, mobilising local resources for road safety encouraging effective action and integrating activities were being met. The four reports documenting individual projects were of a high standard, in each case relying on outcome measures in terms of behaviour change or achievement. The particularly exciting feature of the program was the ambitiousness of the projects and the extent to which the local partnerships had developed some of these in a short time. Particularly impressive were projects in two municipalities which were designed to assist disadvantaged people to obtain a driving licence, prompted by a recently-introduced requirements for all drivers to gain 50 hours supervised driving practice before proceeding to P-plates and solo driving. For people who have little or no access to cars this is very difficult. Disadvantaged communities were faced with the prospect of increases in unlicensed driving and unregistered vehicles, and further disadvantage in employment. The programs assist participants, many of whom have limited literacy skills, pass their learner's permit. Community volunteers enable participants to achieve the required amount of practice, thanks to the availability of cars donated by an employment services provider (75% of jobs require that the person be able to drive as part of the job, or are accessible only by personal transport).

Other programs which have delivered well include a designated driver program which appears to have reduced assaults as well as drink driving, a heavy vehicle program which encourages drivers and operators to adhere to a code

of practice while at the same time promoting appropriate behaviour in relation to heavy vehicles to the driving public in general, and a program to put speed reminder signs on wheelie bins which achieved a substantial reduction in operating speeds, even on days when the bins weren't put out.

5.2 Overview of the program

It is clear that CRSP has achieved much in less than two years of operation. The impressive aspects of CRSP's performance which can be compared to experience in other Australian jurisdictions are:

- programs running in 12 municipalities, representing approximately 40% of the municipalities in the State
- the four evaluation reports to date are of a broadly equivalent standard to the best papers at Local Government road safety conferences
- some of the programs already running or about to be launched are ambitious in their scope, and have involved intense collaborative effort in overcoming major challenges.

This success is due to DIER being able to build on two pre-existing developments:

- the experience of other organisations in Australia (and, to a lesser extent, overseas) in developing community based programs
- Tasmania's existing commitment to community development, and the existence of an effective community development capacity in Local Government.

DIER's achievement has therefore been to recognise the opportunities these two developments presented, and to make full use of them in developing a vibrant program with strong commitment from stakeholders, and achieving this in a very short time. The commitment and enthusiasm of DIER staff involved in the program was a point spontaneously mentioned in the three programs visited as a critical factor in bringing this about.

6. RELEVANCE FOR DEVELOPING COUNTRIES

The road safety challenges facing developing countries have been well documented (e.g. Peden et al. 2004). These challenges arise both from dealing with the current burden imposed by today's road trauma and in preparing to deal with the even higher levels of road trauma anticipated as increasing prosperity results in increasing motor vehicle travel. Action to improve road safety has not so far been sufficient to reduce road trauma, although progress has been evident in some countries in measures such as crashes per 10,000 vehicles.

The reasons for this are complex and cannot readily be generalised across countries. However, the following features of many developing countries seem relevant:

- a strong focus on economic development, so that government priorities have up to now been focussed on the provision of essential infrastructure rather than its safety performance
- diffuse ownership of the road system among different central government agencies and local government
- relatively tight control of government agencies from the centre, with little experience of engaging with other government agencies at the local level
- no direct ownership of the problem by the major government agencies.

As the Ottawa Charter recognises, there may be much more awareness of the extent of the problem at the local level since the victims are recognised as individuals from local communities and families, and not remote statistics. It is much easier for local government to be aware of the road trauma cases in the local hospital system than for central government officials, far removed from the crash locations and the affected communities. It may take some time for central governments to move beyond mere recognition of a problem to engage in effective action to reduce crashes, and even longer to allocate realistic budgets.

In view of the immediacy of the impact, local government may be more willing to engage in actions to improve road safety. Once the decision to engage in road safety has been taken, then smaller size of the organisation and its geographic concentration should make it easier and quicker to begin implementing action.

Many of the problems faced in developing countries would seem as though they could possibly be addressed through community programs. For example, Thailand's dominant road safety problems relate to motorcycle use, and are related to non-use of helmets and drink-riding (Tanaboriboon et al. 1999; Kasantikul et al. 2005). There have been several locally-based campaigns in Australia and the US to counter drink-driving and drink walking from which developing countries could draw direct inspiration. However, the issue of helmet wearing would call for a fresh approach.

Tasmania's success with community road safety should give developing countries the confidence that community road safety programs are feasible. Although Tasmania was one of the first parts of Australia to be settled by Europeans, the state itself has a population of less than half a million, and the local government areas included in the LGRSP to date have populations which range from just over 5,000 persons to approximately 50,000 and therefore have relatively small bases to draw on in terms of resources and expertise. Most of the smaller communities depend largely on primary industry and the processing of primary products.

Some internet sources are now available which give a good idea of the types of projects and activities which have been successfully implemented at the local level in developed countries. The most comprehensive of these is the US National Highway Traffic Safety Administration's 'Safe Communities' site:
http://www.nhtsa.dot.gov/safecommunities/ServiceCenter/index.htm.

Although this is somewhat daunting in terms of the amount of material available, there are good examples of programs and case studies of their implementation. The Municipal Association of Victoria's website has some clear guidelines and materials for setting up a range of projects and activities, and advice on how to set up a local road safety plan http://www.mav.asn.au/saferoads . In addition, many municipalities in developing countries have outlines or more detailed accounts of their road safety plans available through their municipal websites.

REFERENCES

Cairney, PT (2002). *Community road safety in Australia and New Zealand.* Austroads Report AP-R214.

Cairney, PT (2005). *Evaluation of the Community Road Safety Partnership program.* ARRB Consulting, Contract Report VC 71472-1.

Kasantikul, V, Ouellet, JV, Smith, T, Sirathranont, J and Panichabhongse, V (2005). *The role of alcohol in Thailand motorcycle crashes.* Accident Analysis & Prevention 37(2) p. 357.

Peden, M, Scurfield, R, Sleet, D, Mohun, D Hyder, AA, Jarawan, E and Mathers, C (2004). *World report on road traffic injury prevention.* World Health Organisation, Geneva.

Tanaboriboon, Y, Ruengsorn, D, Chadbunchachai, W, and Suriyaongpaisal, P (1999). *Analysis of traffic accidents through hospital's trauma registry records – case study of Khon Kaen.* Thailand IATSS Research 23(1), pp. 115-24.

THE EFFECTIVENESS OF A CONTINUOUS PAVED SHOULDER TO REDUCE MOTORCYCLE CONFLICTS AT JUNCTIONS

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ABSTRACT

The road safety target set for Malaysia is 3 fatalities per 10,000 vehicles by the end of 2010. The provision of paved shoulders to segregate motorcycles from other traffic is one strategy being adopted to reduce motorcycle accidents. However, the current practice of terminating paved shoulders at junctions, and the absence of proper motorcycle lane standards, is hampering the successful implementation of this strategy.

This paper describes a study undertaken to examine the effectiveness of providing a continuous paved shoulder to reduce motorcycle conflicts at a T-junctions. The effects of the treatment on motorcycle speed and paved shoulder usage were also studied. This was done by collecting and analysing traffic conflict, spot speed and paved shoulder usage rates by motorcyclists at the junction 'before' and 'after' the treatment period.

The study revealed a statistically significant reduction in overall traffic conflicts as well as particular conflict types after the treatment. These results supported the hypothesis that this treatment does reduce overall conflict. Further, it was found that, while the number of some conflict types decreased, the number of one conflict type increased. However, the increase in this conflict type was not statistically significant at the 5% significance level.

The mean speed of motorcycles after treatment was found to be less than the mean speed prior to treatment, and also statistically significant, at all three designated locations. This reduction was also reflected in the 85th percentile speed.

There was an increase of up to 37.5% in paved shoulder usage by straight-through motorcycles and up to 82.7% for left-turning motorcycles following the introduction of the treatment. These increases were also statistically significant ($p<0.05$).

It was concluded that the provision of continuous paved shoulders at junctions is effective in reducing motorcycle conflicts. It is recommended that further research be conducted on safety aspects of the treatment.

1. MOTORCYCLE ACCIDENTS AND CASUALTIES

The increase in population and motorisation in Malaysia has inevitably led to an increase in the number of road traffic accidents. The number of accident increased from 56,021 in 1978 to 250,429 in 2000. As motorcycles constitute a large proportion of registered vehicles, the number of motorcyclists involved in road accidents contributes significantly to traffic problems in Malaysia. Radin et al. (1995a) reported that the overall relative risk of injuries to motorcyclists is about 20 times higher that that to the occupants of passenger cars. This is primarily because the motorcycle offers little protection to the riders and pillion passengers in the event of a collision. This is consistent with the findings of the Royal Malaysian Police (PDRM, 2000) which reported that, in 2000, 60% of fatalities involved motorcyclists and pillion riders (Figure 1). This clearly indicates that the serious attention given to this vulnerable group is strongly justified.

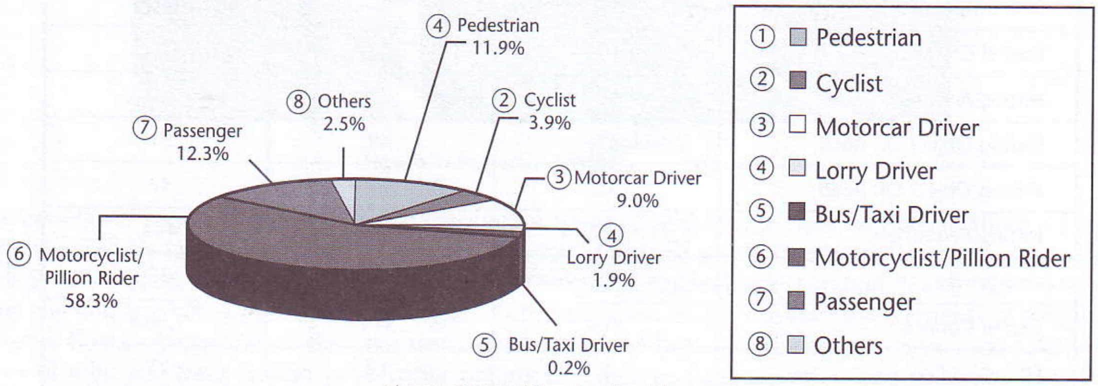

Figure 1: Fatalities by Road Users
Source: Royal Malaysian Police (2000)

The majority (36%) of fatal and serious accidents in Malaysia occur on Federal Roads (PDRM 2000) as shown in Figure 2. This is to be expected because these roads have high traffic volumes, non-control access and pass through areas of development.

It is also important to note that PDRM (2000) indicate that 50% of the motorcyclists and pillion passengers involved in fatal road accidents are between the ages of 16 and 30 years. This suggests that most motorcyclists are young, lack riding experience and have inadequate knowledge of safe riding practices. These fatalities represent a huge economic loss to the community since 75% of the fatalities among motorcyclists are from working communities and 95% are male.

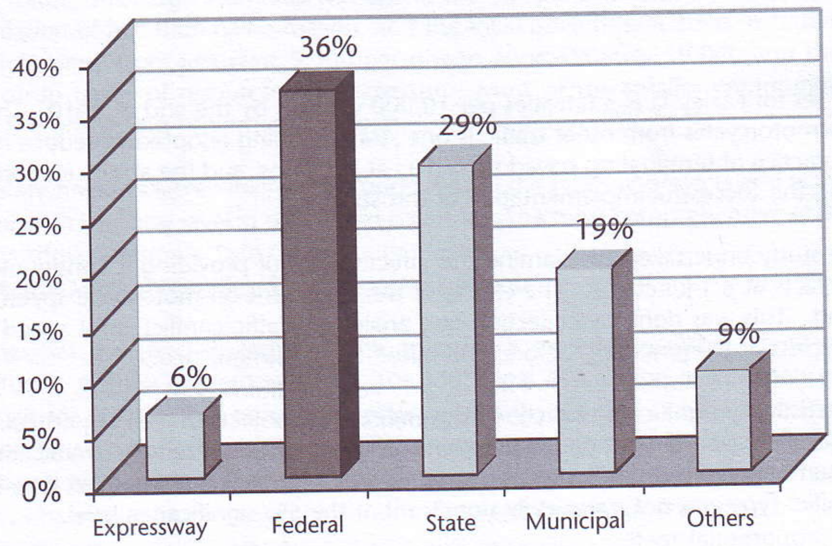

Figure 2: Motorcycle Accidents by Road Category
Source: Royal Malaysian Police (PDRM, 2000)

An analysis of the accident summary data (PDRM 2000) shown in Table 1 reveals that collision types defined as rear-end, right-angle side, angular side and side-swipe constituted about 65% (5,842 cases) of the total fatal and serious accidents. Since these are the typical collision types occurring at junctions, it implies that motorcycle accidents at junctions have a significant effect on the road accident scenario in Malaysia.

Types of junctions include roundabouts, cross-junction, T or Y junction and staggered junctions. PDRM (2000) reported that a total of 2,649 fatal and serious accidents occurred at junctions, with 62% occurring at T or Y junctions (Table 2). This data suggests that strategies or programs initiated to reduce accidents involving motorcycles at junctions should focus on T or Y junctions.

Table 1: Accidents Involving Motorcycles by Type of First Collision

Type of Collision	Fatal	Serious Injury	Total
Head-on Collision	618	795	1,413
Rear Collision	480	832	1,312
Right Angle Side Collision	389	1,078	1,467
Angular Collision	473	1,532	2,005
Side Swipe	351	707	1,058
Forced Collision	10	26	36
Hitting Animal	56	77	133
Hitting Object On Road	42	49	91
Hitting Object Off Road	36	11	47
Hitting Pedestrian	132	312	444
Overturned	13	10	23
Out of Control	716	344	1,060
Others	6	17	23
Total	**3,322**	**5,790**	**9,112**

Source: Royal Malaysia Police (PDRM 2000).

Table 2: Accidents Involving Motorcycles by Junction Type

Junction Type	Fatal	Serious Injury	Total
Straight	2,074	3,109	5,183
Bend	574	714	1,288
Roundabout	20	27	47
Cross Junction	164	429	593
T/Y Junction	408	1,230	1,638
Staggered Junction	90	281	371
Interchange	1	8	9
Total	**3,331**	**5,798**	**9,129**

Source: Royal Malaysian Police (PDRM 2000).

2 CURRENT EFFORT

2.1 Motorcycle Lane

In early 1992, an extension of the separated motorcycle lane on Federal Highway FT002 was undertaken and Radin et al. (1995b) reported that the number of motorcycle accidents dropped significantly immediately following the opening of the motorcycle lane. There was a clear downward separation of cumulative numbers of motorcycles accidents with respect to the predicted cumulative means of accidents. In another study, Radin et. al. (2000) carried out a more detailed analysis along the extended track. They developed a model which showed that motorcycle accidents were directly proportional to the cubic power of traffic flow and reduced by approximately 39% if an exclusive motorcycle lane was provided. In another study, Radin and Barton (1997) suggested that the benefit-cost ratio associated with providing an exclusive motorcycle lane ranged from 3 to 5 depending on the cost of accidents to the nation. These studies imply that motorcyclists are safer when segregated because motorcycle-vehicle conflicts are reduced when the speed differential between motorcycles and faster moving vehicles is reduced. An example of an exclusive motorcycle lane is shown in Figure 3.

Figure 3: Exclusive Motorcycle Lane

Though the benefits of segregating motorcycles from other types of vehicles are clear, at present there are no specific standards for motorcycle lanes in Malaysia. The best available standards are 'A Guide on Geometric Design of Roads' (Arahan Teknik Jalan 8/86, 1986) and 'A Guide to the Design of Cycle Track' (Arahan Teknik Jalan 10/86, 1986) published by the Public Works Department, Malaysia. Both guidelines briefly covered the elements of design required for an exclusive track. A number of design parameters such as vertical and horizontal curve radii follow the basic requirements of a bicycle track design while other parameters such as superelevation and sight distances are in line

with the requirements of highway design. As a result, most design parameters have to be judged midway between the standard highway design and the bicycle track design.

The problem of developing standard is further aggravated since the guidelines do not cater for with-flow exclusive motorcycle lanes where motorcycles travel along the paved shoulder and without any access control. This includes paved shoulder treatments at non-signalised junctions.

2.2 Paved Shoulder

Currently, most Road Authorities provide paved road shoulders for emergency use and also as lateral support to the pavement. Their usage by motorcycles is limited due to the existence of Clause 53 of the Road Traffic Rules (1959) which can be interpreted as prohibiting the use of the paved shoulder except in an emergency (Figure 4).

Figure 4: Paved Shoulder

The current practice of terminating paved shoulders at junctions attempts to address the ambiguities in the 'right of way' rule whenever the path of a motorcycle on the paved shoulder is crossed by traffic turning into a junction. However, it is not clear whether a motorcycle crossing a curved solid line needs to give way. Furthermore, requiring motorcycles to stop and give way to turning vehicles at every junction is not practical and may discourage motorcyclists from using the paved shoulder.

3. STUDY METHODOLOGY

A study was carried out to evaluate the effectiveness of a continuous paved shoulder in reducing conflicts involving motorcycles at T-junctions. The effects of the treatment on the motorcycle's travelling speed and paved shoulder usage were also studied.

In selecting a suitable junction, criteria such as high traffic volume, high motorcycle volume (more than 20% of total traffic), continuous paved shoulder and classification as a main junction by the Road Authority were used. The study was carried out at a junction between Federal Route FT 3217 (previously B2) with Jalan Kassim (a State Road). There are more than 44,754 vehicles per day (November 1999) with motorcycles accounting for 26% of the traffic. Figure 5-8 shows the layout and views of the junction 'before' and 'after' the treatment.

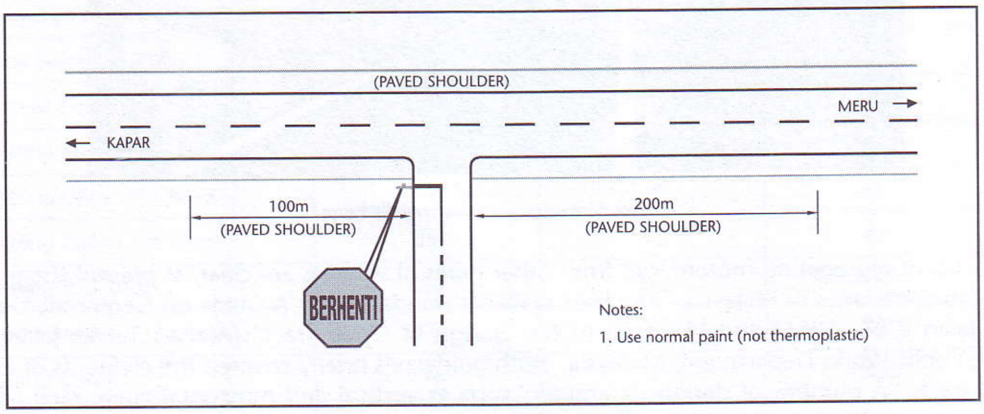

Figure 5: Junction Layout Before Treatment

Figure 6: View of Junction Before Treatment

Traffic conflict technique was used as a tool in assessing the effectiveness of the treatment in reducing conflicts. 'Conflicts' were defined as any evasive action by motorcyclists with other motorcyclists or vehicles to avoid a potential collision. Five types of conflicts involving motorcycles were observed during a 9-hour period 'before' and 'after' the treatment. Figure 9 shows the type of conflicts observed.

In studying the effects of the treatment on the motorcycle's travelling speed, spot speed measurements were taken randomly at three designated locations. At each location 200 samples of motorcycle speed were taken during the 'before' and 'after' treatment period (Figure 10).

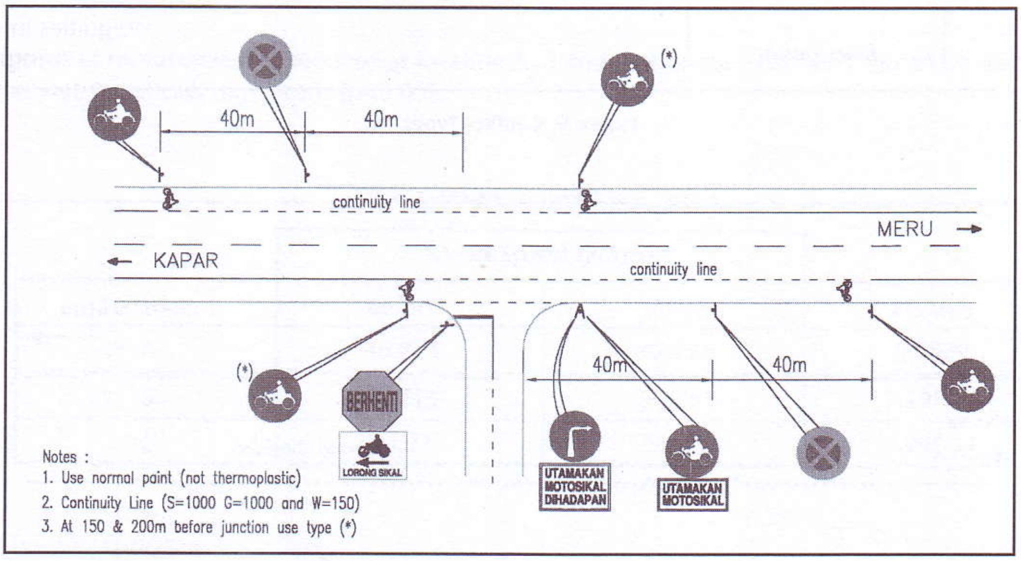

Figure 7: Junction Layout After Treatment

Figure 8: View of Junction After Treatment

Traffic volume 'before' and 'after' the treatment was also collected. The similarities in traffic volume, together with the layout characteristics, would confirm their compatibility as matched pairs. In addition, traffic volume at the treatment junction was used to observe motorcyclists' behaviour with respect to the use of the paved shoulder.

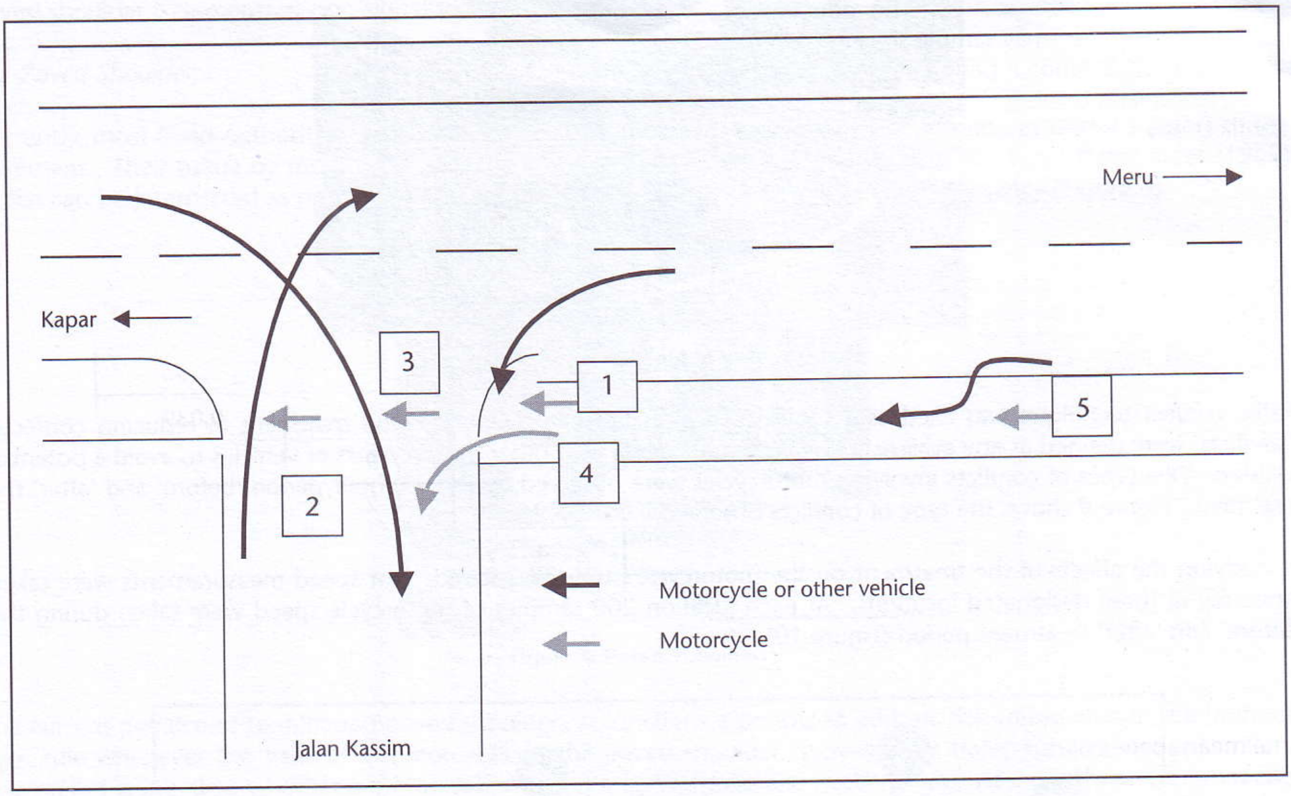

Figure 9: Conflict Types

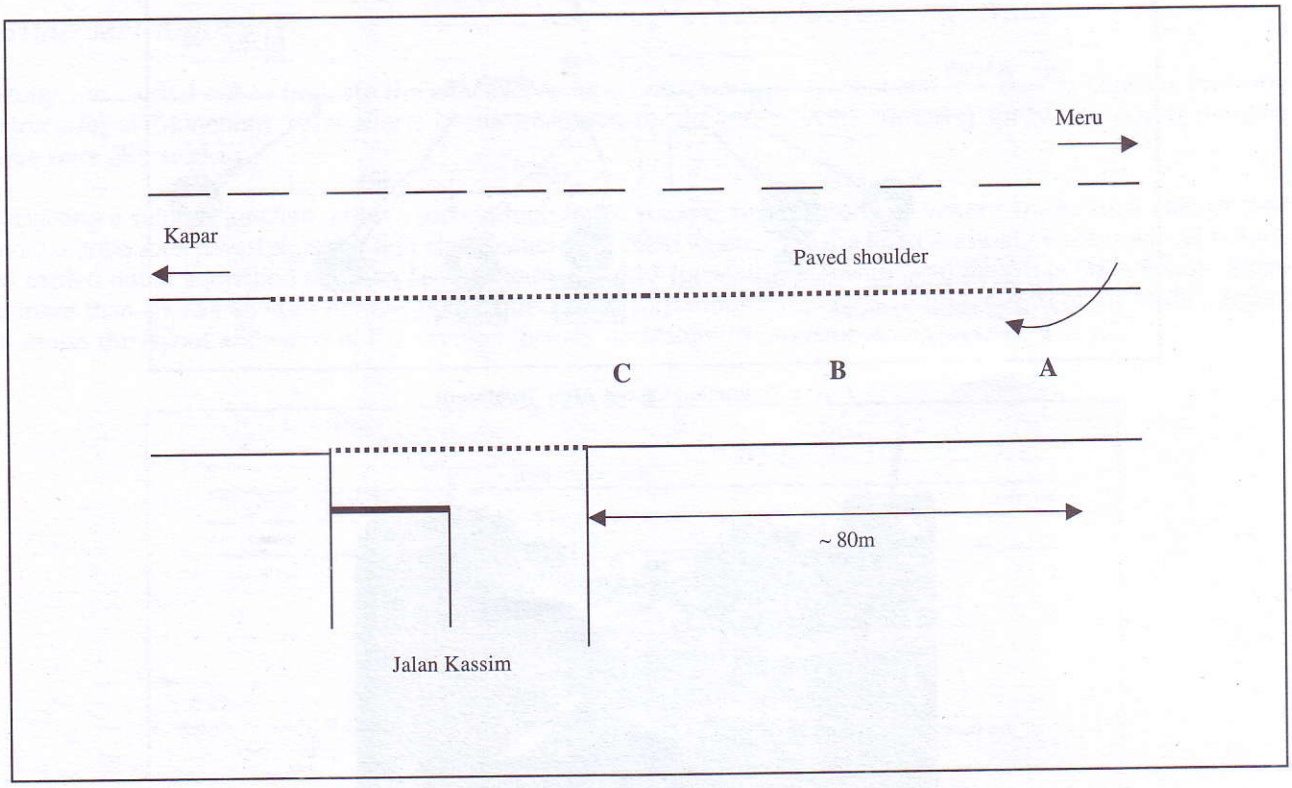

Figure 10: Designated Locations on Spot Speed Measurement

4 RESULTS

4.1 Traffic Conflict

It can be seen from Table 3 that the reduction in overall conflict and individual conflict for conflict types 1 to 3 was statistically significant ($p<0.05$). The reduction in type 4 conflicts was, however, not statistically significant ($p>0.05$). This was due to the small sample sizes (4 before and 1 after). A possible explanation for this low number is that, over the 9-hour observational period, this type of conflict may not be a critical problem at this type of junction. Also, it involved vehicles turning slowly from opposite directions and the drivers were more cautious. The increase in type 5 conflicts was also not significant ($p>0.05$), which implies that the increase was not due to the treatment.

Table 3: Statistical Analysis of Conflicts

	Treatment Junction		Control Junction		
Conflict Type	Before	After	Before	After	P-value
1	12	3	9	11	0.036
2	8	1	7	8	0.039
3	8	1	8	9	0.037
4	4	1	3	2	0.490
5	2	4	1	1	0.673
Total	**34**	**10**	**28**	**31**	**0.002**

4.2 Speed

The mean speeds of motorcycles are reduced at location A, B and C after the treatment. It can be seen in Table 4 that this reduction was statistically significant ($p<0.05$).

Table 4: Statistical Analysis of Speed

	Mean Speed (km/h)		
Location	Before	After	P-Value
A	45.875	42.775	0.0009
B	44.215	39.165	1.29E-06
C	44.22	38.145	4.99E-11

4.3 Paved Shoulder Usage

The study found that there was a statistically significant ($p<0.05$) increase in usage of paved shoulder by motorcycles travelling from Meru-Kapar and Meru-Jalan Kassim (Table 5).

Table 5: Statistical Analysis of Usage of Paved Shoulder

Direction	Before (%)	After (%)	P
Meru-Kapar	11.4	37.5	0.0
Meru-Jln. Kassim	48.8	82.7	1.14E-14

5. DISCUSSION AND CONCLUSIONS

Before the proposed treatment, a total of 34 conflicts occurred at the junction. These were mainly related to the undefined right-of-way for motorcycles travelling straight from Meru to Kapar or turning left from Meru to Jalan Kassim. This was further aggravated by driver expectation that paved shoulders serve as emergency lanes and that motorcycles should not be using them.

The treatment proved to be effective in reducing the overall number of conflicts from 34 to 10 which was statistically significant at the 5% significance level ($p<0.05$). Proper demarcation using lines continuously across the junction provides a clear right-of-way for motorcycles, encourages lane discipline among motorcyclists and increases other driver expectation regarding the predicted travelling path of the motorcycle when crossing the junction. The merging on the shared lane requires other vehicles to 'give way' and travel at the same speed as the motorcycle. This helps to reduce differential speed and hence serious conflict.

The implementation of the treatment also resulted in a reduction in the mean and 85th percentile speed of motorcycles. In a study on travelling speed and crash risk (Kloeden et al. 1997) it was suggested that there were at least three reasons why a small reduction in speed may make such a large difference to the risk:

- Small differences in vehicle speeds, before braking begins, can result in large differences in impact speed. This is because the braking distance of a travelling vehicle is proportional to the square of the speed.
- Even small differences in impact speed make a large difference to the probability of serious injury. The reason for this is that the force of the crash varies with the square of the impact speed.
- Small differences in speed are associated with differences both in the time to the collision and the ability to avoid an accident. When speeding is involved, less time is available for either the speeding driver or the other road user to take evasive action. Thus, any reduction in motorcycle speed will help to reduce the potential severity of accidents at T-junctions.

The study found that only 11.4% of 'straight-through' motorcyclists and 48.8% of 'left-turning' motorcyclists used the paved shoulder despite its provision. However, after the treatment the usage of the paved shoulder increased to 37.5% and to 82.7% by 'straight-through' and 'left-turning' motorcyclists respectively.

It is considered that he use of paved shoulders can be increased if efforts are made in the following areas:

- Review the existing Road Traffic Rules 1959 to allow motorcyclists to use paved shoulders.
- make the use of paved shoulder by motorcyclist mandatory by law and prohibit other road users from encroaching onto them.
- carry out an effective media campaign to educate motorcyclists as to the benefits of paved shoulders.
- Use coloured pavement and proper traffic control devices to encourage motorcyclists to use the paved shoulder at junctions (e.g. see Figure 11).

An increased utilisation of continuous paved shoulders across junctions by motorcycles may also lead to an increase in the utilisation rate at the link section because the continuity nature of the paved shoulder which will allow unimpeded motorcycle travel. This will legitimise motorcyclists' rights to use of the roadway and increase awareness among other road users on the safety needs of motorcyclists. Ultimately it should lead to an overall improvement in motorcycle safety along the Federal Route.

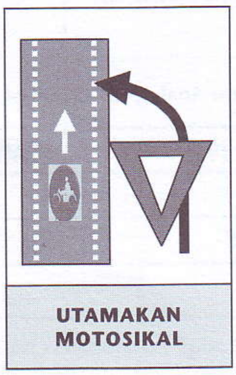

Figure 11: Example of Advisory Signs for Coloured Surfacing

It is concluded that the treatment carried out was effective in reducing conflicts involving motorcycles at T-junctions. It is hoped that this study is another step forward in the development of a 'motorcycle facilities' standard and the realisation of Malaysia's national road safety target of 3 fatalities per 10,000 vehicles by the end of 2010.

REFERENCES

Arahan Teknik Jalan 10/86 (1986). *A Guide To The Design Of Cycle Track.* Jabatan Kerja Raya (JKR), Malaysia.

Arahan Teknik Jalan 8/86 (1986). *A Guide On Geometric Design of Roads.* Jabatan Kerja Raya (JKR), Malaysia, pp. 92-98.

Highway Planning Unit (1999). *Road Traffic Volume Malaysia 1998.* HPU Kementerian Kerja Raya Malaysia.

Laws of Malaysia (1994). *The Road Transport Rule 1959.* (Compilation of 40 rules), ILBS.

Kloeden, CN, McLean, AJ, Moore, VM and Ponte, G (1997). *Travelling Speed And Risk Of Crash Involvement.* NHMRC Road Accident Research Unit, The University of Adelaide, Australia, pp 46-49.

Radin Umar, RS, Mackay, GM and Hills, BL (1995 a). *Preliminary Analysis of Motorcycle Accidents: Short-Term Impacts of the Running Headlights Campaign and Regulation in Malaysia,* Journal of Traffic Medicine Vol. 23, No. 1, pp 17-28.

Radin Umar, RS, Mackay, GM and Hills, BL (1995b). *Preliminary Analysis of Exclusive Motorcycle Lane Along the Federal Highway F02, Shah Alam.* Journal of IATSS Research 19(2), pp 93-98.

Radin Umar, RS and Barton, E, (1997). *Preliminary Cost Benefit Analysis of Exclusive Motorcycle Lane.* Journal of REAAA No. 9, pp 2-6.

Radin Umar, RS, Mackay, GM and Hills, BL (2000). *Multivariate Analysis of Motorcycle Accidents and The Effects of Exclusive Motorcycles Lanes in Malaysia.* Journal Crash Prevention and Injury Control 2(1), pp 11-17.

Royal Malaysian Police (PDRM) (2000). *Statistical Report of Road Accidents in Malaysia : 2000.* Traffic Branch, Bukit Aman, Kuala Lumpur.

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TRAINING NEEDS FOR THE REGION

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ABSTRACT

REAAA's mission is to "meet the needs of members for professional and organisational understanding and cooperation both within and beyond the region". In order to meet this mission, one of the primary goals of REAAA is to improve the delivery of technical services to members. This paper discusses the general issue of training needs for the region, activities to date and planned future activities. Possible avenues for conducting these activities, including the ASEAN Regional Road Safety program, are also discussed. The information was presented at the Workshop on "Training Needs for the Region" conducted during the 4th HORA Meeting in Bangkok in June 2005.

Also included in the paper are the results of a questionnaire completed by HORA delegates at the meeting on the major issues that could be addressed in training courses or seminars. The topic identified as the most important in terms of training needs was 'program development and monitoring', with over half the respondent rating this as one of their top three issues. Other issues rated highly included road safety auditing, risk assessment, standards and guidelines, cost-benefit analysis, and data types and analysis. Vulnerable road users (pedestrians, cyclists, motorcyclists, etc.) did not rate highly in terms of training needs, their vulnerability being already well acknowledged.

1. BACKGROUND

REAAA's mission is to "meet the needs of members for professional and organisational understanding and cooperation both within and beyond the region". In order to meet this mission, one of the primary goals of REAAA is to improve the delivery of technical services to members. Some major advancements have recently been made in the provision of improved technical services to members - including seminars associated with REAAA Council meetings, regional seminars and roadshows, and a course for road asset managers conducted in Bangkok in 2001. However, some concerns were raised at the 2nd HORA meeting held in Cairns, Australia, in May 2003. These included: a lack of engineers trained in road safety and asset management skills, the need to increase the level of the transfer of knowledge and technology in the region, the need for more professional training in asset management skills and the need to identify specific training needs and providers.

This paper discusses the general issue of training needs for the region, activities to date and planned future activities. Possible avenues for conducting these activities, including the ASEAN Regional Road Safety program, are also discussed. The information was presented at the Workshop on "Training Needs for the Region" conducted during the 4th HORA Meeting in Bangkok in June 2005. Also included in the paper are the results of a questionnaire completed by HORA delegates at the meeting.

1. OUTCOMES OF PREVIOUS HORA MEETINGS WITH RESPECT TO TRAINING NEEDS

2.1 2nd HORA Meeting

The 2nd HORA meeting, held in May 2003 at the Cairns Convention Centre, Queensland, Australia, included two Workshops which focussed on Road Network Asset Management and Road Safety.

Road Asset Management

In terms of Road Network Asset Management, it was agreed that, in many countries, there was a lack of engineers trained in the skills of asset management and that these skills were not typically included in undergraduate courses and needed to be acquired "on the job".

Participants were invited to briefly introduce the current road asset management problems facing their country, solutions carried out and to suggest ways in which REAAA might facilitate the regional transfer of this knowledge and technology.

The building blocks for effective asset management were seen to be national databases of road stock and its changing condition over time. In most of the participating countries, the availability of funds to create and maintain such datasets was a fundamental problem. An allied issue, critical to most countries, was how to build new infrastructure at a rate commensurate with the rate of growth of traffic. Privatisation is one of the commonly used methods to generate additional funding for the countries' infrastructure. Build, operate and transfer (BOT) policy was noted as the most favourable means for the funding of new roads. However, in some developing countries, there was still a need to first educate road users to the benefits of using toll roads before privatisation could be effectively promoted.

The fundamental problem confronting many countries was how to balance the need for a rapid growth in infrastructure with the need to manage the maintenance demands. This again led to the conclusion that the training of professionals in the principles of asset management was vital.

Managing axle overloading was seen as one of the highest priority issues for most countries, while some also experienced frequent natural disasters such as typhoons and earthquakes, which compounded the problems of planned maintenance management. (The effects of the recent tsunami would also apply to this situation.)

A related problem was how to make sure that concessionaires conformed to Government standards on road building and life-cycle maintenance in managing the road asset. For example, Australia and New Zealand based their measures on long-term, performance-based contractual systems

Road Safety

In this Workshop each country was requested to present an outline of their road safety issues, including institutional arrangements, problems, solutions and general strategies.

Within the region road safety is administered by a variety of Governmental agencies such as the police force, transport ministry, works ministry, highway authorities, etc. There was a general shortage of trained professionals and an under-developed research capacity (except, for example, in Australia, New Zealand and Japan). There also appeared to be a relatively widespread lack of community and political commitment and under-resourcing.

Many countries reported effective specific control measures such as speed cameras, general traffic enforcement, specific public education campaigns, road safety audit and blackspot programs, anti-skid treatment on roads, street lighting, motorcycle and bicycle lanes, seat belt laws, helmet usage, motorcycle lights during the day, etc. However, it was noted that, while heavy penalty and stringent conditions for non-compliance of government directions may be an effective means of promoting road safety, many of the developing countries had major difficulty achieving the appropriate level of implementation.

The Asian Development Bank (ADB) reported on the guidelines for road safety in the region that it had developed. It was noted that 450,000 people die of road accidents in Asia Pacific countries each year and 4,000,000 people are severely injured. Unfortunately, these were probably underestimates as hospital reports revealed large differences compared with studies conducted by transport authorities.

One solution suggested was the establishment of an independent official government road safety department, with an independent budget as a separate entity from any ministries. This budget could be extended to finance enforcement costs in the promotion of road safety issues. In addition, there was also a need for research institutions to study road safety issues and provide appropriate advice.

It was concluded that the basic problem was not the lack of known countermeasures but the great difficulty in achieving the implementation of the most effective measures. Less thought should be given to the "three E's" (engineering, enforcement, education) and more to the "4C's" (co-operation, co-ordination, collaboration and commitment). The importance of professional capacity and a strong research effort were also reinforced.

2.2 3rd HORA Meeting

At the third HORA meeting in Manila in October 2004, members expressed very strong support for a Workshop on 'training needs' and the following general considerations were offered.

- Training needs should be considered as a part of a more general program of 'human resource development'. There should be scope to develop a framework for formulating a program to deliver 'knowledge sharing'.

- A major problem in the Pacific region is the loss of trained staff to the private sector and overseas. Emphasis should be placed on upgrading technical staff to the professional level because they are more likely to stay in the region.

- A major issue is how to assess the 'competency' of the trainer. It has often been found that the 'expert system', when implemented, was not competent enough to conduct the auditing.

- Training could be expanded to include the establishment of a network to exchange information at both the bilateral level and multi-level. This could be particularly useful for a topic such as 'road safety'.

The following two broad topics were suggested.

Road Maintenance

planning and budgeting (HDM4)

privatised maintenance

road funding (road user costs)

pavement design and maintenance

cement and lime modification

use of local materials (e.g. coral)

contract management for engineers

design and construction of chip seal pavements

asphalt, PMBs, etc.

quarrying operations – blasting, safety management, etc.

Road Safety

traffic management

traffic calming

enforcement

legal issues

road corridors

Members also provided feedback on the topic of 'Privatisation of Road Facilities', the other issue to be addressed at the 4th HORA Meeting. Major issues identified were private/public partnerships and the allocation of risk.

3. TRAINING COURSES CONDUCTED OR PLANNED THROUGH REAAA

3.1 Course for Road Asset Managers

This course was conducted in Bangkok, Thailand, on 7-9 May 2001. Funding, including in-kind support, was provided by a number of organisations including the Asian Development Bank, the World Bank, Transit New Zealand, ARRB Transport Research and the REAAA, including the Malaysian and New Zealand Chapters.

About 50 senior road managers from 29 countries took part in the course which was conducted by ten experts in the area. The course was conducted in three stages as follows.

Stage 1 - Reform

- Role of roads in developing economies
- International trends in management reform
- Reform in road financing

Stage 2 - Tools

- Achieving mandates for reform
- Strategic planning and resource allocation
- Systems for decision support

Stage 3 - Safeguards

- Road and traffic safety
- Environmental, social and poverty impacts
- Management and governance

The Course achieved the following objectives:

- It succeeded in providing a valuable service to REAAA member countries and potential members by raising the profile of REAAA in the region.
- It cemented a strong relationship between REAAA and the ADB and World Bank and demonstrated that REAAA could facilitate training if the appropriate level of financial support could be provided.
- It established a mechanism through which REAAA could achieve one of the key objectives of its Strategic Plan as discussed at the commencement of this paper.

3.2 Mino Roadshow

As already discussed, at the 2nd Heads of Road Authorities (HORA) Meeting, there was considerable support for REAAA to develop an active technology transfer program to update skills and keep abreast of changes and improvements in technology. At the REAAA Council meeting held in Hanoi in October 2003, agreement was reached to fully develop a proposal for a Roadshow to be initially implemented in Pacific Island nations, including Samoa, Fiji, and Tonga. The meeting also decided to adopt the name REAAA Mino Roadshow in memory of former President and long serving member of the Governing Council Dr Sadamu Mino.

Investigations carried out by the New Zealand and Australian Chapters, and supported by the REAAA Council members' own experiences, suggested that there was a pressing need in the less developed countries for professional development in various aspects of road management, especially asset management and road safety. It was concluded that there were significant economic, social and environmental implications of any development decisions in these countries and their policy requirements, including the need for a kit of investment tools to effectively analyse proposals and identify preferred policy decisions.

The target Pacific Island Nations have basic road management systems in place but improved data collection and analysis methods, coupled with expansion of their technical knowledge, will assist in improving their ability to make appropriate and economically viable decisions and enhance their ability to analyse risks and returns.

It was agreed that it would be more cost effective to take information training and technology transfer to the recipients. In this way, technology could be transferred within a locally relevant and practical context.

THE WAY FORWARD

Due to the relative remoteness of some countries, opportunities for engineers and technicians to keep abreast of technical advances in highway design, construction techniques and systems – and especially asset management and road safety – are limited.

The constrained financial resources rarely allow the countries' administrators the opportunity to send engineers or technicians on professional development courses conducted in nearby developed countries. Even if finance could be made available, a substantial portion of the professional development that is available abroad is inapplicable to the systems, methods and materials that are most appropriate for the Pacific Island Nations.

The rationale behind the proposal for the Roadshow is that the most appropriate technical assistance that REAAA can provide to these nations is the organisation and conduct of professional development workshops through a Roadshow,

with the program focussing on an agreed set of topics previously selected by each participating nation from a consolidated list of possible topics. The professional development technical content would be pitched at a level that is appropriate for the local audience, recognising that managers, engineers and technicians, from both Government and commercial organisations, are likely to attend the Workshops.

PROPOSED CONTENT

The theme of the proposed Mino Roadshow is "managing road assets and safety to provide community outcomes", with the focus of the content to be on road asset management. This is to increase the benefit to the community through the eventual provision of improved community outcomes.

The broad areas that have been identified as being appropriate include:

- pavement design and rehabilitation
- drainage
- project economics
- risk management

Additional areas identified outside the scope of asset management but also included are Road Safety and Occupational Heath and Safety.

4. TRAINING FOR ROAD SAFETY

4.1 Background

In recent years much has now been documented regarding the escalating levels of death and injury sustained through road crashes. Road safety is increasingly recognised as a social, economic and health problem having particularly adverse impacts on low and middle income countries. No longer is it seen simply as an unwelcome side-effect of road transport. Some 1.2 million people will die on the world's roads in 2005 – 85% of these in low and middle income countries which own only 40% of the world's vehicles. The World Health organisation (WHO) has estimated that, by 2020, death and injury on the road will have become the third ranked cause of 'disability adjusted life years', higher than wars or HIV/AIDS.

Recent figures reported by an ADB/ASEAN study indicate that the Asia-Pacific region contributes 44% of the global road deaths. For ASEAN countries alone the cost was estimated to be in excess of US$15 billion in 2003.

Vulnerable road users, especially children, the elderly, pedestrians and motorcyclists have been identified as being the single largest group of road crash victims; as high as 80% of all casualties in some regional jurisdictions.

4.2 Developing Actions

Regional jurisdictions and organisations such as the ADB, ASEAN and APEC are now well advanced in developing strategies and action plans. These strategic plans address many issues and invariably include institutional capacity building with a focus on training of individuals.

ADB ASEAN ROAD SAFETY STRATEGY

In 2002 the ADB initiated, through the Association of South-East Asian Nations (ASEAN), the development (Phase 1) of a strategy to guide road safety initiatives into the future. In November 2004 the ASEAN Transport Ministers adopted the Regional Road Safety Strategy (Phase 2). This strategy includes capacity building through the establishment of 'centres of excellence' and 'train the trainer' programs including seminars. The ADB/ASEAN regional plan is being circulated in proposal form to organisations with the potential to support initiatives.

Some funding for the training component of the regional plan has been committed by the Global Road Safety Partnership (GRSP) which is active in a number of regional countries. In 2000 the World Bank initiated the GRSP which is essentially a partnership between governments, businesses and civil society organisations dedicated to reducing death and injury on roads, especially in low and middle income countries.

The GRSP is now moving to develop training courses and approaches for people engaged in most aspects of road safety, including the major area of road engineering, often referred to as the road environment. Road system managers need to make decisions in an increasingly complex and demanding environment where the need for trained expertise is becoming more apparent. Up to now the road safety area has not been well serviced by training providers offering a wide range of appropriate courses.

The GRSP will soon appoint a regional coordinator to develop road safety training approaches. An important initial task is the identification of training needs within regional jurisdictions. Consideration of road safety training needs by this HORA meeting is an opportunity to inform and influence the development of the regional training program.

5. HORA WORKSHOP QUESTIONNAIRE

To assist in the development of possible actions, and to identify major issues, delegates were issued with a questionnaire which asked them to rate, in order of priority, 18 issues associated with the general area of road safety. Emphasis was not to be placed on what was the most important issue but rather what were the major issues in terms of training needs. Delegates were free to add other issues they thought appropriate. If possible, delegates were also asked to indicate the type of training preferred, possible 'Centres of Excellence' and estimate the number of officers in their jurisdiction who could participate in the training.

Twenty-one responses were received from the following organisations:

Australia	VicRoads Queensland Department of Main Roads
Bhutan	Ministry of Works and Human Settlement
Brunei	Public Work Department
India	Tamil Nadu Road Development Company Ltd
Indonesia	Directorate General of Highways
Japan	Road Association
Korea	Road and Traffic Association Highway Corporation
Malaysia	Highway Authority
Nepal	Department of Roads
New Zealand	MWH
Pakistan	National Highway Authority
Philippines	Department of Public Works and Highways
Singapore	Land Transport Authority
Sri Lanka	Road Development Authority
Taiwan ROC	China Road Federation
Thailand	Department of Highways Department of Rural Roads
Tonga	Ministry of Works
Vietnam	Bridge and Road Association

5.1 Analysis of Results

The top ranking topic was assigned 1 point and so on to the lowest ranking topic, which was assigned 18 points. The scores were then summed and the topics ranked in terms of score, with the lowest score being the highest priority. In two of the 21 responses, not all topics were ranked in these cases 18 points were assigned to all those topics not rated. The purpose was not to conduct a statistical analysis but rather to identify trends.

An analysis of the responses to the questionnaire suggested that the topics could be divided into eight groups in terms of priority as shown in Table 1.

Table 1: Ranking of Topics in Order of Priority

Ranking	Topic	Points	Comment
1	Program development and monitoring	93	rated in top 3 by 11 respondents
2	Road safety auditing	118	rated in top 3 by 9 respondents
3	Risk assessment	147	rated in top 3 by 7 respondents
4	Data types and analysis	170	
	Standards and guidelines	174	
	Cost-benefit analysis	176	
	Research and evaluation	181	
5	Legislation and regulation	196	
	Crash investigation	207	
6	Coordination with other sectors	219	
	Speed management	226	
	Worksite safety	233	rated in top 3 by 3 respondents
	Heavy vehicles	243	
7	Major and minor roads	259	
	Signage and line marking	259	
	Intersections and lighting	274	
8	Pedestrians and cyclists	285	
	Motorcycles	299	

The topic identified as the most important in terms of training needs was 'program development and monitoring', with over half the respondent rating this as one of their top three issues. Other issues rated highly included road safety auditing, risk assessment, standards and guidelines, cost-benefit analysis, and data types and analysis. Vulnerable road users (pedestrians, cyclists, motorcyclists, etc.) did not rate highly in terms of training needs, their vulnerability being already well acknowledged.

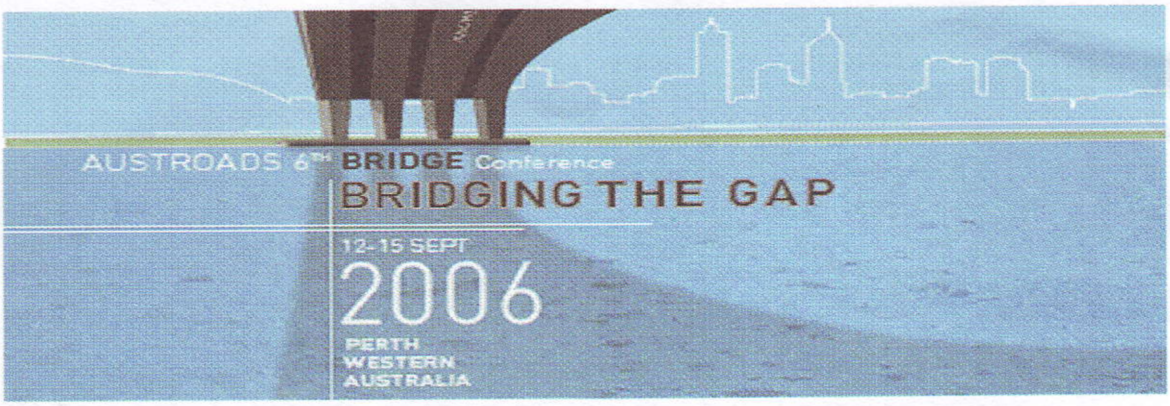
Although of overall low priority, 'workshop safety' was rated very highly by three organisations and other topics of similar low priority were also rated highly by some organisations. This suggests that there may be 'regional' issues which requires further investigation.

In terms of 'types of training', there was an even spread of views and no clear trend emerged. However, there it was evident from the responses that delegates preferred that the issues of highest priority be addressed through courses rather than (shorter) seminars or workshops.

5. CONCLUSIONS

This paper has discussed the general issue of training needs for the region, activities to date and planned future activities. Possible avenues for conducting these activities, including the ASEAN Regional Road Safety program, are also discussed.

Included in the paper are the results of a questionnaire completed by delegates to the 4th HORA meeting held in Bangkok in June 2005 regarding the major issues that could be addressed in training courses or seminars. The topic identified as the most important in terms of training needs was 'program development and monitoring', with over half the respondent rating this as one of their top three issues. Other issues rated highly included road safety auditing, risk assessment, standards and guidelines, cost-benefit analysis, and data types and analysis. Vulnerable road users (pedestrians, cyclists, motorcyclists, etc.) did not rate highly in terms of training needs, their vulnerability being already well acknowledged.



Austroads 6th Bridge Conference

Main Roads Western Australia is pleased to be the host for the Austroads 6th Bridge Conference. The theme of the conference focuses on 'Bridging the Gap' through knowledge, technology, research and development as well as needs versus delivery across generations and communities.

In keeping with one of the elements of the conference theme of 'Bridging the Gap' the organising committee are pleased to advise the introduction of a Young Authors Award with a first prize of $1200 and a second prize of $800. To be eligible young authors must be 35 years old or less as at 31 March 2006. Further information and the Terms and Conditions are available from the conference website.

As has been the case at previous conferences, nominations will be sought for a range of awards. Information on the categories will be uploaded to the conference website in the coming weeks.

Three internationally renowned speakers will be delivering key note addresses during the conference. The organising committee is proud to announce that an agreement has been reached for the following eminent people to participate in the conference:

- **Dr Ernie Evans** a founding Director of Bruechle Gilchrist and Evans Pty Ltd, who has been involved in extensive bridge design work throughout Australia and overseas
- **Dr Roger Dalton** who has a lifetime of experience in bridge engineering in Canada and was awarded the Order of Canada in 2004, the country's highest civilian recognition
- **Dr Bojidar Yanev** who has 30 years experience as a consulting and research engineer in New York and California.

For more information on all conference activities please visit the conference website: www.impcom.com.au/austroadsbridgeconference